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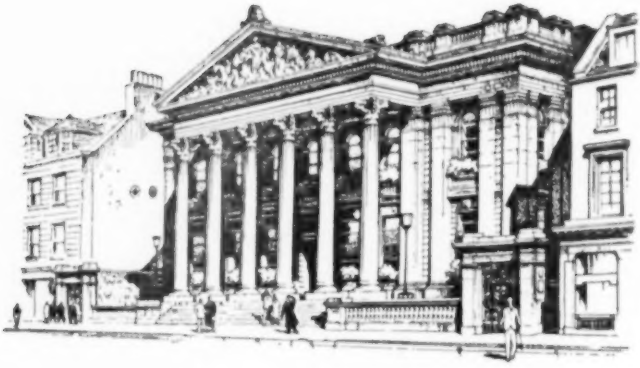

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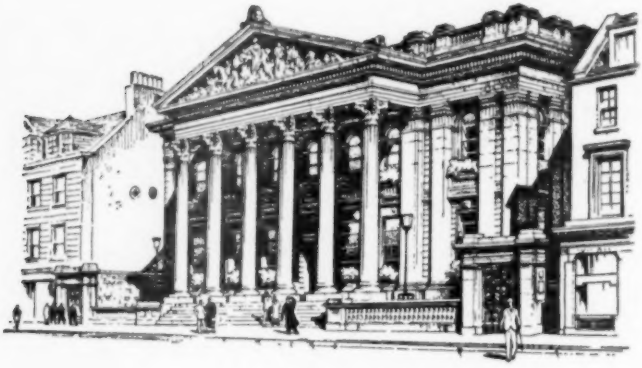

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ROYAL SCOTTISH GEOGRAPHICAL SOCIETY

PROCEEDINGS

MEETINGS OF COUNCIL were held on the 2nd April, 7th May and 16th July 1957.

AWARDS: The Diploma of Fellowship was conferred upon James Barclay Glen, M.A., "for special services to the Society at the Glasgow Centre", 12th February 1957.

ANNUAL GENERAL MEETING

The Annual General Meeting will be held in the Society's Rooms, Edinburgh, on Tuesday, 8th October 1957.

ANNUAL SUMMER EXCURSION

GLASGOW: Members of the Glasgow Centre made a tour by coach to Killin and Aberfeldy, returning by way of the Sma' Glen and Crieff. A visit was paid to the Hydro-Electric Board's Station at Killin, 25th May 1957.

ROYAL SCOTTISH GEOGRAPHICAL SOCIETY'S TOURS

Switzerland and Italy: June-August 1957.

Norway: July 1957.

ERRATA: *S.G.M.*, VOL. 73, No. 1. APRIL 1957

The editor wishes to apologise for the following errors which appeared in the April (1957) issue of the *Magazine*:

Fig. 5, p. 9: the misprints in the names Kiel, Wiesbaden, and Ruhr.

Plate 4: for Berwickshire read Roxburghshire.

Plate 3: for north-west read south-east.

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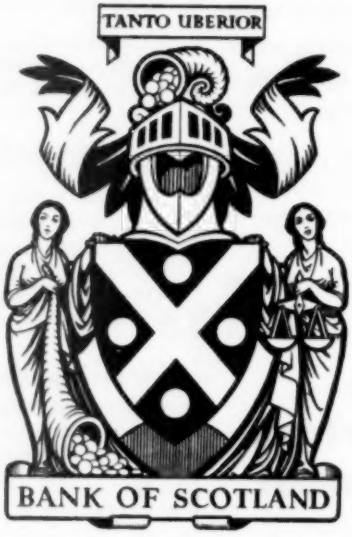

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THE SCOTTISH
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MAGAZINE

Vol. 73, No. 2 September 1957

THE PRIMARY AGRICULTURAL COLONISATION OF SCOTLAND

WILLIAM KIRK

". . . A SEA-CHANGE INTO SOMETHING RICH AND STRANGE."
(Shakespeare, *The Tempest.*)

SOME four thousand years ago the first farmers began to arrive in Scotland. They came from the south by devious routes and for diverse reasons, and introduced into these northern, alien lands a new way of life and thereby a new force in the process of landscape development. Though few in number and ill-equipped to meet effectively the full challenge of dense forest, swamp, and peat bog, nevertheless in some areas they pioneered a technique of environmental change which ultimately was to lead to a transformation of terrain no less significant than the vast physical changes which had preceded their coming. Though by no means the first inhabitants of a land left hard by ice they were the first human communities in whose economic activities it is possible to recognise something more than mere parasitism on natural environment, and to them is owed the primary selection of agricultural locations. For such reasons they rank high in the geographical laboratory of Scotland's past, and this essay seeks to review in the light of recent archaeological literature,[1] what manner of men these pioneers were, and thence to examine, so far as it is now possible, the environmental problems and potentialities they encountered, and the values which appear to have influenced their spatial behaviour.

THE COLONISTS

It would appear that the earliest colonists, possibly following in the wake of explorers and traders, came by sea and made their first landfalls on the south-western coasts of Scotland in Luce and Wigtown Bays, on the shores of Arran and Bute, and along the margins of the long, narrow sea inlet of Loch Fyne. About the same time similar groups of farmers were establishing themselves on the Irish seaboard

near Carlingford Lough and spreading along the coasts of Down and Antrim, and since both groups used the same sort of great chambered tombs for the successive interments of their dead, and shared a distinctive style of pottery it can be inferred that they had a common origin and for some time in the ensuing period maintained close cultural relations. Even if the evidence be judged insufficient to allow us to picture with Childe "grey seas as bright with Neolithic Argonauts as the Western Pacific is today"[2] the reality of sea communication linking the scattered colonial settlements of the North Channel region must be admitted.

Unfortunately, as is so often the case in prehistoric times, the archaeological record provides much more information on how the settlers were buried than how they lived. Apart from a few rather inconclusive domestic sites such as those at Lyles Hill in Co. Antrim,[3] Rothesay in Bute[4] and among the sand-dunes of Glenluce in Galloway, almost the entire evidence for the origins and economic activities of the North Channel communities consists of material recovered from the inner chambers of megalithic tombs.[5] Most of this suggests southern origins, and sea routes *via* the Irish Sea. Their pottery, for example, includes unornamented, round-bottomed vessels, obviously developed from leathern prototypes and showing affinities with pottery used by the earliest farming communities of the chalklands of Southern England, and highly finished, decorated ware whose origins have been traced back to the Atlantic seaboard of Portugal, Southern France and Brittany. As Piggott has pointed out,[6] the latter type with its various forms and motifs suggests the presence of at least traders if not actual colonists from the Biscayan coasts—a link which is further substantiated by the discovery at the tomb of Cairnholy in Galloway of a ceremonial jadeite axe petrologically almost certainly of Breton origin, and by the remarkable similarity of ornamentation on stones and plaques of schist found in both regions. The basic forms of tomb construction, also, point to origins in that area and of course ultimately to the Mediterranean coastlands.[7] Whether voyages were made direct from these southern regions or *via* intermediate staging points is uncertain, but at least recent evidence confirms the "western route of coastwise sailing" suggested by earlier writers and implies a strong maritime element in the economic life of the earliest Scottish colonists.

Other grave goods indicate the nature, if not the details, of their agricultural activities. Stock-breeding, for example, is attested by the bones of domesticated sheep, pigs and cattle, and the disproportionate number of bones of immature cattle suggests that lack of sufficient fodder to carry the herds over the winter resulted in wholesale autumnal butchery of young beasts. That this practice was not just an expression of the northern location is shown by similar discoveries at contemporary sites in Southern England, where the recovery of large quantities of such bones in the silted ditches of the causewayed 'camp' of Windmill Hill has led Piggott to infer that enclosures of this type were primarily designed as central cattle corrals used by stock-breeders of the downlands.[8] Indeed such a custom prevailed generally in Britain until

as late as the eighteenth century when the introduction of new crops and rotations helped to solve the problem of winter feed. Most of the North Channel settlers would also appear to have supplemented their meat diet by hunting, fishing and grain growing. The latter, probably carried on by the womenfolk of the community once the initial clearances had been made, is attested by saddle querns discovered at Townhead, Rothesay and by the impressions of grains of small spelt (*Triticum monococcum*) and emmer wheat (*Triticum dicoccum*) found on potsherds from Dunloy in Ireland.[9] Barley was also cultivated and this hardy cereal appears to have assumed greater importance in more northerly and harsher environments.

From the evidence available it is thus possible to infer that we are dealing with the pioneer settlements of peasant communities organised into groups which found communal expression in the construction of family burial vaults. Since the latter seem to have been used for many generations, their distribution (Fig. 1) provides a useful, albeit incomplete, indication of the tracts of country permanently occupied by the settlers, and in view of the scanty evidence of actual settlement sites is the only guide we have to the nature of the agricultural values which governed the pattern of land utilisation at that time. Primarily mixed farmers, with an apparent emphasis in certain localities on pastoralism, it is probable that the colonists' labours would be mainly directed to the clearance of plots of land suitable for cultivation and to the supervision and protection of their herds during the seasonal movements to and from the various pastures of high moorland and lower woodland open to them in this area. From their equipment, however, one can infer that the agricultural round-of-the-year was not so time-consuming as to prevent, for example, the younger men joining in hunting expeditions into the interior, armed with bows and arrows tipped with finely-worked, leaf-shaped arrowheads of flint,[10] or sailing the inshore waters and canoeing the estuaries and rivers in quest of fish, wildfowl and materials lacking in the immediate vicinity of their home bases. In most colonial movements, wherever and whenever they have taken place, it is from adventurous activities such as these that the drive to expand, to reach out into new ground, has usually sprung.

In this setting of sea-borne pioneer settlement let us then picture the process of expansion in terms familiar to geographers from their studies of such settlements at other times and in other parts of the world, bearing in mind of course the limitations of such inference.[11] At first no doubt the primary settlements required as big a labour force as they could breed or attract to their communities, but sooner or later, depending on the nature of the local environment, a stage is usually reached with such pioneer groups when the size of the primary community presses hard on the resources of the farm unit, and, particularly under conditions of primitive subsistence farming, the area of land required to support it becomes unmanageably large. In such an event only two alternative courses are open to survival—expansion of the bases of economy or reduction of numbers. While the Scottish evidence provides hints that some communities resorted to the former

alternative by engaging in maritime trade or specialised production of pottery, for example, there are no indications at present of the growth of sizeable trading or industrial settlements, nor indeed of the growth of substantial villages such as characterised parts of contemporary Europe. On the contrary most communities would seem to have solved their problem of reducing population pressure by hiving off daughter colonies. The tract of pasture just too far across the divide to be used economically by the mother colony, which the hunting party came upon last autumn ; the excellent harbour backed by sandy soils which the fishermen had found two summers ago, when they had been forced to run for shelter in a sudden gale which sprang up when they were four days sailing along the coast—these were the sort of sites at which the secondary colonies were established ; and to which, one can imagine, the young folk took a skeleton farming equipment to start the process of pioneering all over again on a new frontier. For a time no doubt they kept in contact with the old home farms, but gradually, left to their own resources the old ties would weaken and divergent elements in their original culture would begin to develop, either as a result of forgetting, or experimentation in a new environmental setting, or the infusion of fresh ideas from new contacts.

Regarding the distribution of the chambered tombs and other records as mobility traces in this respect, it would seem that such onward movements took the farmers up into the high interior of Galloway and Southern Ayrshire, along the southern margins of the Central Highlands to the headwaters of the Earn, to Skye and the Outer Hebrides, to the northern coasts of Sutherland and Caithness, to the intricate interior channels of the Orkney and Shetland Isles, and, following the discovery of the Great Glen route with its relatively easy canoe portages, to the shorelands of the Moray Firth. In view of the difficulty of the terrain and the small numbers of settlers who seem to have been involved, such colonial movements would take a considerable time, spanning many generations, and during this time it appears that further waves of new colonists moved in from the south, in some cases leap-frogging the older settlements. At least, such an interpretation would in part account for the fact that although collective burial continued to be practised the chambered tombs themselves exhibit a considerable morphological diversity. Whereas the ' gallery-grave ' was the characteristic type built by the early North Channel settlers, increasingly the ' passage grave ' became popular during the secondary, expansionist phase of settlement. Within the ' passage grave ' class of tomb there are many variations, such as have been described by Piggott *et alia*,[12] and such differences obviously must be taken into account when considering the regional expression of colonisation, but in the present context the most significant feature is that it is from the most northerly margins of settlement that the greatest insight into the everyday life of the settlers has been obtained, largely as the result of excavations conducted by Childe.

On a low platform of weathered flagstone in the Bay of Skail, Orkney, a complex of stone huts and passages, fossilised long ago by sand encroachments at the now famous site of Skara Brae (Fig. 2) was

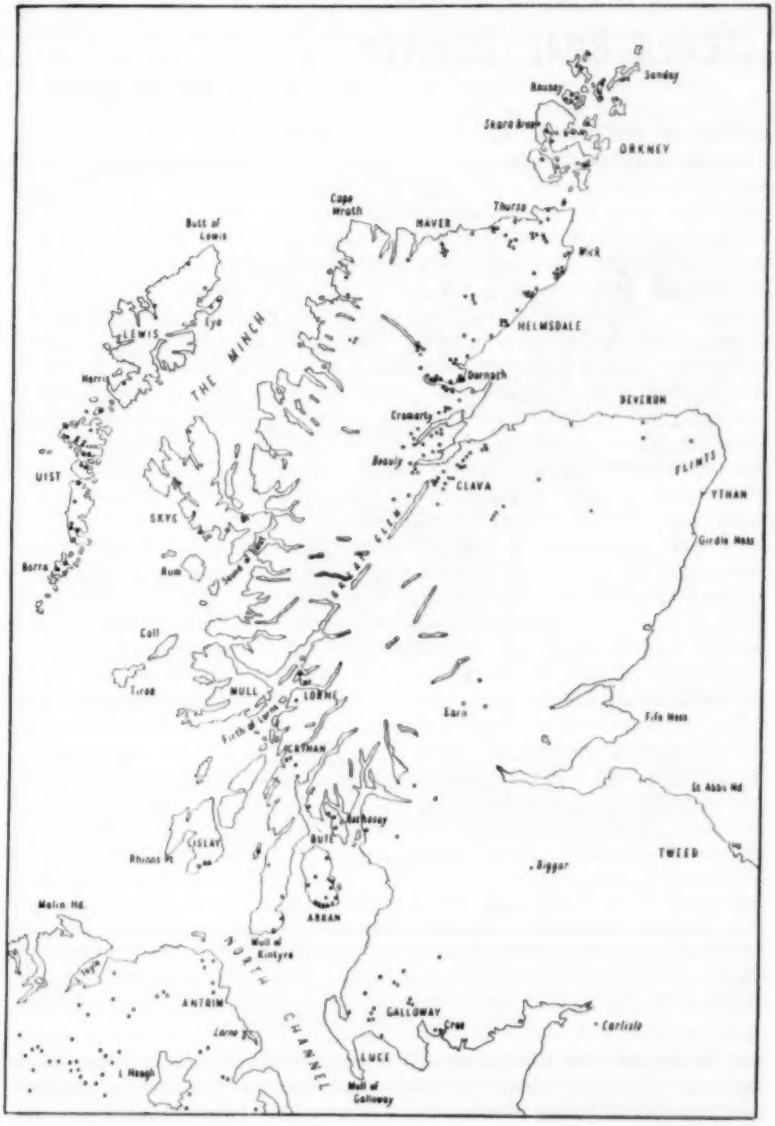

Fig. 1. Distribution of Chambered Tombs (*after Scott, Childe, Piggott, et al.*). Note essentially western and coastal nature of distribution.

partly exposed again by gales in the middle of last century, and successive excavations have revealed a hamlet of eight adjacent dwellings.[13] Built of flagstone slabs laid in horizontal courses, in a manner which

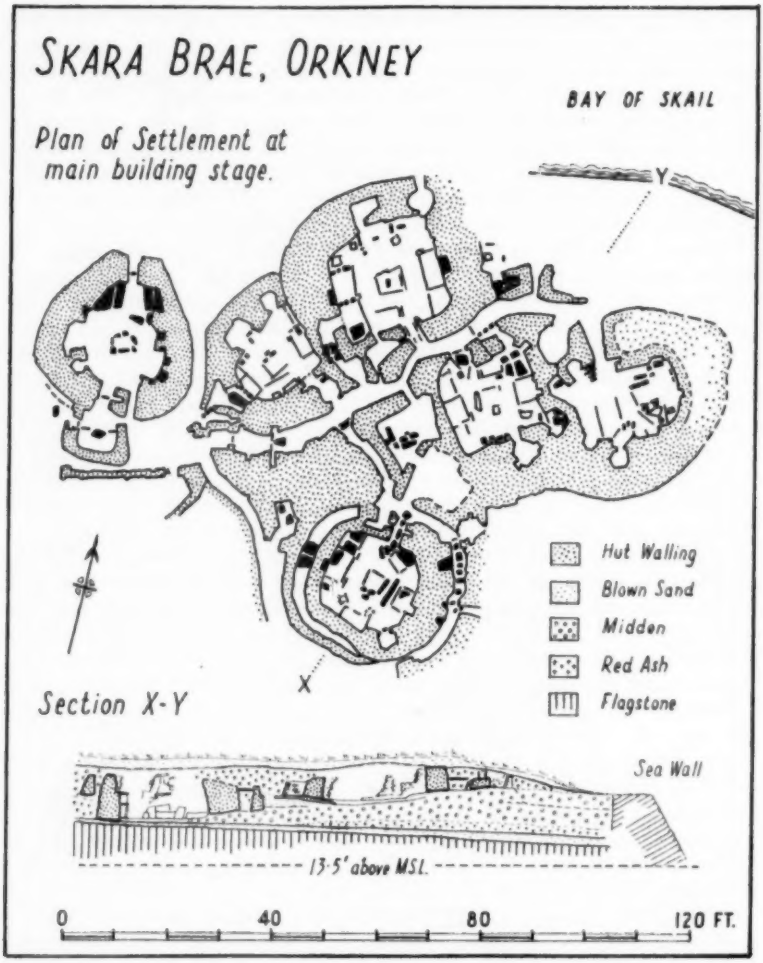

Fig. 2. Skara Brae ; showing Plan of settlement during main occupation phase, and Section (*after Childe*). Note that wind-blown sand had already covered the flagstone platform prior to human settlement.

was to characterise northern architecture for thousands of years, each hut was irregular in shape externally and entered by a narrow passage-way capable of being blocked by a stone slab. Inside, each hut comprised a square-shaped living-room, with rounded corners, slightly corbelled walls and cellular annexes. The floors were of clay and paving stones, and usually in the centre was a hearth, contained by flagstones set on edge and yielding traces of peat fires. On each side of the hearth against the hut walls similar stone slabs were used to construct bed-boxes, which, along with shelves and ' dressers ', appear

to be translations into stone of domestic equipment normally made of wood in contemporary settlements of the southern forests. Each hut opened on to a system of covered passages terminating in narrow doorways, so that the entire unit could be closed to the outside.

Evidence from the hut floors and midden material in which the whole site was embedded shows that, in the main, the inhabitants were breeders of sheep and cattle—the former belonging to an early species with long slender limbs, the latter to a breed with some characteristics, such as a marked sexual dimorphism of horn cores, not paralleled elsewhere in prehistoric Britain. While autumnal slaughter of cattle is well attested there is little to indicate that the village flocks were reduced in this way. Pig bones are rare, as might be expected in a comparatively treeless environment, and those that have been found appear to belong to wild rather than domesticated breeds. There are no indications of dog, horse, or reindeer, and no testimony whatever of grain growing. Childe suggests that the small stone mortars which were recovered were probably used to pound fish bones rather than corn. Fishing and fowling, however, were certainly practised. Crabs and shellfish, particularly limpets, were eaten, and the occurrence of cod and coal-fish, which are bottom feeders, would imply line-fishing from boats, although no fish hooks have been recovered. Nor apparently were the islanders averse to whale meat if whales were stranded on their shores, but there is no evidence that they were actually hunted, and it would be wrong to overstress the position of whales, and seals, in the island economy.

For some years Skara Brae stood alone in the archaeological record of the earliest farming settlements of the far north, and for this reason was exceedingly difficult to place, but more recent excavations at Rinyo, Rousay [14] have not only revealed another Orcadian site alike in structure and economy, but, through the greater stratigraphical precision possible there and the additions to the range of material equipment they produced, have greatly assisted in establishing the general provenance of both sites. Each produced a large quantity of stone and bone implements (see Fig. 3). The bone adzes, chisels and awls have, as Childe has pointed out,[15] striking resemblances to the equipment of the earlier Maglemosian hunting folk of Northern Europe, while the stone tools such as flagstone ' hatchets ', clubs, and knives show affinities to implements of ancient lineage attributed by Gjessing [16] to the Circumpolar Stone Age—that ultimate, environmental blind alley of antique cultural forms. The many curious carved stone balls (Fig. 3. 3-4), the function of which has never been satisfactorily explained, are paralleled from various localities of eastern Scotland, notably Aberdeenshire, but unfortunately with no firm dateable associations. Pottery from Skara Brae and Rinyo, however, does have significant chronological analogues. Some plain sherds have features similar to those of pottery found in Orcadian chambered cairns, while their flat-based decorated ware resembles that obtained from Scottish sand-dune areas such as Hedderwick, Gullane and Glenluce, and indeed from sites in Southern England, such as Woodhenge in Wiltshire and the submerged land surface at Clacton on the

Essex coast.[17] At the latter two sites it is associated with Beaker pottery, while at Rinyo itself fragments of a beaker occurred in the horizon marking the latest phase of occupation.

The north-south links implied by the common features in what has been termed Rinyo-Clacton ware can be interpreted in various ways. Piggott, for example, suggested in 1936 that such pottery styles were derived from Holland, but in more recent investigations has inclined towards Scott's view that they represent coarse provincial variants of Iberian prototypes reaching their present British localities by two routes—one by the Atlantic seaways to the Hebrides and Orkneys, and secondly by the English Channel coasts to Wessex and East Anglia.[18] Such an interpretation is supported by the apparent discreteness of the northern and southern provinces of the culture, but the discovery of intermediate sites at Scunthorpe, Scarborough and Hedderwick suggest that east coast movements should not be ruled out.

Generally speaking, however, far less is known of the movements of early farmers into Scotland by east coast routes than by the west.[19] In part this is due to the fascination which the chambered tombs and megalithic monuments of the west and north have held for archaeologists, and to their greater survival rate in comparison to less substantial structures. As will be seen from Figure 1, however, chambered tombs are virtually absent from the eastern coastlands and the nature and origin of the earliest farming communities there must be traced from other sources. The occurrence of long barrows as far north as Aberdeenshire and Banff, of abundant leaf-shaped arrowheads and flint axes, and of characteristic baggy, undecorated pottery, such as the shouldered bowls found at Easterton of Roseisle in Moray, have led to the suggestion that many of the early settlers came from North-eastern Yorkshire, deriving their culture ultimately from the ' Windmill Hill ' farmers of the southern chalklands. This would be in accordance with the role often played by the Yorkshire Wolds in the process of Scottish colonisation in prehistoric times. Few indications of the type of farmstead used by these people survive, but at Kemp Howe in the East Riding an oblong excavation in the chalk with a raised dais at one end and a narrow inclined passageway at the other, and with evidence of a central row of posts and collapsed roof timbers, has been interpreted[20] as a dwelling-house of this period, while at Easterton of Roseisle oval pits may represent hut basements. Pottery from the latter site has produced a grain impression of Naked Barley, a six-rowed species which is similarly recorded by Helbaek from Eday, Orkney.[21] So far, however, there has been no record of wheat-growing, which played such an important part in southern farming at this time, although this may be due to the paucity of eastern Scottish material rather than the absence of the crop in the agriculture of the northern settlers. It is to be hoped that further archaeological investigations, particularly, one would suggest, in the sand-dune areas of the east coast, will increase the very scanty knowledge we have of these early colonists.

However the impression one gains from recent investigations, and the material which is available, is that the colonisation of the east was by no means a simple process, carried out by a single stock of

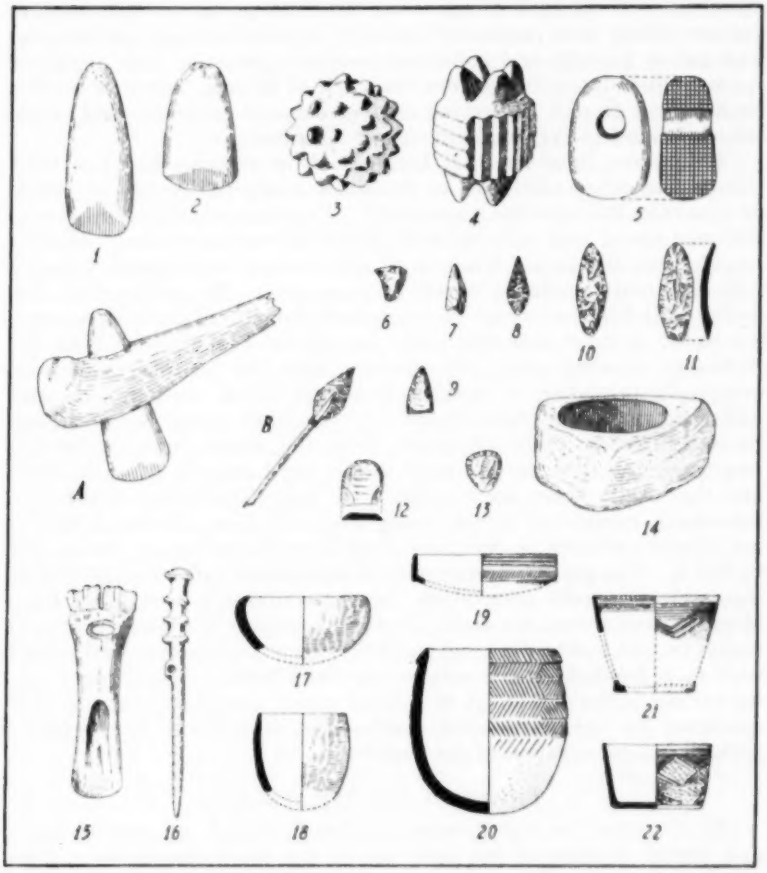

Fig. 3. A selection of the material equipment of the early farming communities. *1-2* Stone Axes; *3-4* Carved Stone balls, Skara Brae; *5* Mace Head, Arran; *6-9* Flint Arrowheads; *10-11* Plano-Convex Flint Knives; *12-13* Flint Scrapers; *14* Stone Mortar, Skara Brae; *15-16* Bone adze and pin, Skara Brae; *17-20* Chambered Tomb Pottery; *21-22* Rinyo-Clacton Pottery. *A* and *B* show methods of hafting axes and arrowheads.
Scales: 17-22. Scale $\frac{1}{12}$; 3, 4, 14. Scale $\frac{1}{4}$; Remainder, Scale $\frac{1}{2}$.

farmers. The trek northwards from southern pastures took a considerable time, possibly longer than the sea-borne settlement of the island world of the west, and while it would appear that some elements may have outstripped the rest and established themselves on northerly beach-heads the landward movement of the farming frontiers seems to have been comparatively slow. The farmers here had wider potential agricultural terrains to occupy and at the same time greater physical obstacles to circumvent, such as large expanses of wet heavy land with dense forest, and in such an environment colonial surges would tend to dissipate their energy more quickly than along the more

circumscribed channels of the west. In consequence hybridisation of culture arising from protracted contacts between farming communities and native hunting and collecting peoples appears to have occurred quite frequently on the eastern lowlands of Britain, and it was often such hybrid groups, preserving ancient cultural elements, that established themselves eventually in eastern Scotland.

It appears, however, that before such movements had run their course, the entire east coast of Britain was affected by the incursion of new colonists from the continent.[22] These were farmers too, but of different racial and cultural stock from the earlier settlers. Hailing mainly from the Lower Rhinelands they were a broad-headed people who favoured individual burial in short stone cists rather than collective burial in communal vaults, and manufactured finely-decorated, flat-based pottery conventionally known as Beakers (see Plate 3). Although showing some acquaintance with the use of metals, and eventually providing a market for bronze goods such as axes and daggers, from an agricultural point of view they do not seem to have been technically more advanced than the earlier settlers. Grain impressions on their pottery from sites in the Lothians, Aberdeenshire and the Moray Coast are invariably of Naked Barley and while they may have introduced flax-growing from the Low Countries this is not directly attested in Scotland until later, according to Jessen and Helbaek. The general nature of their equipment indeed suggests that they were primarily pastoralists, thereby continuing a trend we have already noted among the earlier northern farmers. Capable of ranging widely in search of pasture and game they appear to have pressed inland with their herds from the eastern seaboard thereby producing a distributional pattern (Fig. 4) to a large extent complementary to that exhibited by the chambered tombs, and completing the primary agricultural colonisation of the country.

Environmental Influences

By the time the first farmers reached Scotland the natural floral and faunal stocking of the land was in the main completed and its physical configuration was not grossly unlike that which exists at present.[23] The tundra conditions which had prevailed in Late Glacial times had long since vanished from all except the most lofty and exposed places, and had been replaced during the post-glacial climatic amelioration by extensive forests and their associated fauna, while the major fluctuations of sea level, instigated by isostatic and eustatic changes consequent upon the melting of the ice-sheets, had already occurred. Nevertheless certain physical modifications significant to the process of agricultural colonisation do appear to have been operative at this time, and since the reconstruction of past environments constitutes a necessary preliminary to any geographical discussion of past human adaptations we must estimate the incidence of such changes—even though it must be admitted at the outset that the Scottish evidence is woefully scanty and much of the reconstruction, particularly of the contemporary vegetation, is dependent on inference from adjacent countries where Quaternary studies are at present more advanced.[24]

Fig. 4. Distribution of Beaker pottery (*after Mitchell, et al.*). Note essentially eastern nature of distribution, with concentrations in Aberdeenshire and S.E. Scotland. Some of the western specimens were recovered, as late deposits, from chambered tombs.

As a result of palaeo-botanical studies of peat-bogs and lacustrine sediments it is generally accepted now that for some three thousand years prior to the first indications of agricultural activity most regions

of North-western Europe had experienced a moist maritime climate characterised by changeable ' Atlantic ' weather. During this period the climatic optimum for tree growth in post-glacial times appears to have been achieved in most lowland areas, and birch and pine forest witnessed the invasion of alder, oak, elm, and in some districts warmth-loving trees such as lime. In Northern Britain, however, most of the sites so far examined by pollen-analytical techniques suggest that birch remained an important component of the forest cover, and although mixed deciduous woodland certainly does appear to have extended over the better-drained terrains it may be doubted if poorly drained lowland tracts and exposed Highland areas benefited from the higher temperatures of this period, accompanied as they were by heavy rainfall and probably high winds. Indeed it is highly probable that the ' Lower Turbarian ' peat bogs of Lewis's system [25] formed in many parts of Scotland during this period, a moisture threshold having been passed where peat growth inhibited colonisation by trees. Presumably gleying of ill-drained lowland soils and podzolisation of thin upland soils were attendant phenomena.

While this ' Atlantic ' period undoubtedly set the general ecological scene for the first agricultural communities there are some indications that certain modifications to this pattern occurred both prior to and during the centuries of colonisation. In recent years the reality of a Sub-Boreal period of warm, dry, continental climate following the Atlantic conditions has been questioned by several workers. Godwin,[26] for example, points out that in many areas no drastic fall of lake levels such as one would expect under drier conditions has been observed, and that it would be generally wrong to over-emphasise the warmth, since the Climatic Optimum was already past and certain warmth-loving species were declining in importance in northern latitudes. Undoubtedly it would be folly to expect Britain to provide evidence of continentality to the same extent as the peat bogs of Germany which gave rise to the term Sub-Boreal, but at the same time it must be admitted that certain areas do show signs of drying out during this period. Many of the peat bogs in Ireland and Scotland exhibit recurrence surfaces similar to those of continental examples indicative of drier conditions followed by peat rejuvenation, and while various western cases suggest that the main recurrence of peat growth, attributable to climatic deterioration in the Sub-Atlantic period, may have occurred much earlier than generally believed further east, this could well be explained in terms of the climatic distinctions recognised today between western and eastern conditions. Probably the most convincing evidence of a drier phase, however, is to be found in the widespread remains of birch and pine forest sandwiched between upper and lower peat formations in the Scottish Highlands. This ' Upper Forestinian ' zone of Lewis's terminology represents tree colonisation of the dried-out and weathered surfaces of extensive peat bogs, with that vigorous colonist birch in the van, and, while there still remains some uncertainty as to the chronological provenance of Lewis's main horizons, there can be little doubt that the spreading peat blanket which suffocated this forest formed in Sub-Atlantic times, and that the

forest layer itself will prove to be the Scottish equivalent of the continental Sub-Boreal.

On the other hand, this may not necessarily imply great climatic change, as in many areas the threshold between forest and peat growth would appear to be rather delicately poised, with a number of circumstances able to tip the balance one way or another. In various lowland bogs for example, an improvement of drainage sufficient to allow birch, alder and willow colonisation may have resulted at this time from the lowering of the base level of river erosion, as the sea withdrew from the higher ' Litorina ' strandlines it had reached during the main Atlantic period. Furthermore this same lowering of sea-level from the so-called ' 25-foot Raised Beach ' seems to have exposed considerable quantities of beach sand on some sections of the Scottish coastlands, which under drier conditions was blown inland across the raised beach surfaces, formed dunes, and modified soil and vegetation in various coastal localities. A reasonable conclusion would be, however, that although not so great as once believed, certain climatic changes were during this period modifying the Atlantic vegetational climax, particularly in those areas marginal to forest growth because of excessive moisture, and for a time at any rate worked in favour of trees. The first farmers were confronted then by a great forest, as yet virtually untouched by man, and consequently the springs of their behavioural patterns can be sought in the varied potentials of different forest tracts.

Although the earlier inhabitants of Britain undoubtedly knew the use of fire there are no indications that planned clearance of forest was carried out by its agency. Forest fires either natural or accidental no doubt occurred and produced ecological scars that took some time to heal, but hunting and collecting communities would gain little benefit from such phenomena. With the settlement of agriculturalists, however, forest clearance was a necessity, and, as Iversen has shown,[27] this appears to have involved the calculated use of fire and resulted in ecological changes of more than a temporary nature. Some form of '*Brandwirtschaft*' or ' slash-and-burn ' method such as is widely practised by primitive farmers in forest environments seems to have been employed. The process probably went something like this. In the spring-time preceding the year of cultivation the undergrowth and small trees of the site selected for clearance would be uprooted and the larger trees ring-barked to stop the sap rising. A summer's drying facilitated the felling of the big timber by stone axes, and the firing of the dead undergrowth early in the following year. No attempt would be made to remove the tree stumps since no ploughing was to be done, but the ashes from the burning provided a dressing rich in potash for the forest soil. Suitably worked by hoe or digging stick such plots were capable of yielding a return on seed grain for a few years, but then suffered from the difficulty which affects all primitive farming on forest soils—soil exhaustion. By this time other clearings would have been prepared, however, and the old ones deserted in succession as they became exhausted. Natural regeneration of the woodland followed, with, one should imagine in Scotland, birch playing a major

role owing to its speed of colonisation. Given sufficient time the forest reclaimed its own and closed its ranks in the wake of the shifting agriculturist, but in some cases the process could be prolonged or even permanently checked. If sufficient forest of suitable character did not exist within a community's territory it could well happen that old plots were used again before recuperation was complete and in addition the grazing and browsing of farm stock in abandoned clearings probably delayed plant colonisation. Mixed oak forest, particularly on lighter soils, provides a good deal of ground vegetation and low foliage suitable for animal fodder in any case, but where it had been opened up by farmers there would be even more pasture available, comprising grasses and the weeds of cultivation which make their first appearance in pollen diagrams at this time.[28] Driven on by the goad of soil exhaustion and using fire, axe, flocks and herds it is not difficult to imagine the power of even small numbers of peasant colonists to initiate significant ecological changes in Cool Temperate forests where regeneration is relatively slow in any case. Their action would bear particularly heavily on those lighter, poorer tracts where environmental conditions themselves precluded rapid regeneration, and the extension of heathland on the sandy soils and weathered drift of North-western Europe during this period offers a well-attested example of this process.

The farmers thus faced a paradoxical situation. All the evidence we have suggests that the majority were skilled and experienced woodsmen to whom forest as such presented no insuperable obstacle to settlement unless it were associated with other environmental difficulties. Indeed, as we have seen, their agriculture perforce depended largely upon the utilisation of forest soils and it is probable that their assessment of what constituted good agricultural land would be based upon the type of forest cover they found it bearing. But their selection of agricultural locations involved not only the potentiality of the land but the technical resources at their command, and the resultant distributions suggest that these values were often in conflict. Facility in clearing woodland in many cases is inversely related to its arable potential. Thus, leaving to one side the truly negative areas where marsh or altitude allied with forest to make any sort of agricultural settlement virtually impossible at this stage, the first farmers were obliged to select locations from a variety of terrains ranging between those where the forest was thin and could be cleared rapidly and those involving much greater labour. The former would often provide good grazing grounds, but was obviously deficient in some environmental resource which resulted in thin growth, low powers of recuperation, and hence poor arable potential. The latter at the outset offered poorer grazing but higher arable potentialities and swifter recuperation. Given the situation of pioneer colonisation and equipment described in the first section of this essay it is hardly surprising that the majority of the Scottish settlers appear to have opted for the intermediate and lighter forest soils. In eastern and southern Scotland for example, the heavier lands of the Tweed, Forth and Tay lowlands, central Ayrshire, lower Nithsdale and Annandale, the Clyde valley and parts of the coastal lowlands of Aberdeenshire and Strathmore provide little

evidence of the presence of farmers during this colonial period. The majority of the signs of occupation coincide with well-drained soils of a light to medium character—light loams of the middle slopes above frost hollows and often with southern aspects ; light silts overlying terrace gravels and out of reach of river floods ; dry-point sites in the lowlands, often provided by glacial gravel mounds ; and sandy coastal zones. In such situations slope, drainage and soil conspired with the lightness of vegetal cover to attract farming communities.

The operation of similar values and locational decisions at this time are, of course, widely recognised in Western Europe, whether in relation to the loess lands of the continent or the loam terrains and chalklands of southern Britain, but what is less generally appreciated is that the selection of such locations was bound eventually to have repercussions on the economic life of the settlers. The interplay between environment and human communities is not a one-way process and when man acts as an agent of ecological change he cannot expect to remain unchanged himself. As long as the utilisation of the lighter lands was restricted they served the purpose of mixed farming well enough, but as the farming population multiplied and the demands on such terrains intensified, their arable value would undoubtedly decline and increasing emphasis be placed on pastoral farming as grassland and heath expanded. Such would appear to be the general influence of Cool Temperate forest on farming colonists with Warm Temperate agricultural traditions.[29]

While ecological influences appear to have been of great importance, particularly in eastern and southern Scotland, one should not disregard other environmental controls in the primary agricultural colonisation of the land. In western and northern Scotland the forest existed too, as is shown by the presence of willow, hazel, oak, pine and birch charcoals within the chambered tombs of North Uist,[30] alder and hazel twigs from an early deposit at Skara Brae, and by post holes and alder, birch, willow, pine and oak charcoals at Rinyo, but in many areas, especially in the north, the forests seem to have been thin and in such areas the sheer immensity of land and sea would appear to have exerted more powerful influences than in the east.

The majority of the tracts in the west with evidence of agricultural occupation during this period occur close to the seaboard, below an altitude of 400 feet, where gentle slopes and fairly light soils were available. Most of this zone has been subjected to marine action at various times since the Pliocene period, and although only vestigal traces of the early strandlines remain, the raised beaches of the Late Glacial Sea (± 100 feet) and Litorina Transgression (± 25 feet) are prominent features of the coastal margins (Plate 1).[31] Achieving a maximum amplitude off the south-western approaches to the Great Glen they decline in elevation northwards, southwards and westwards, being absent for example, in Orkney and the north-west coast of Lewis. The Late Glacial beaches are also missing from the inner reaches of many of the sea lochs where valley glaciers apparently were still extant at the time of high sea level, while in other places the raised beach deposits merge into, or are buried by fluvio-glacial sands and gravels washed

down by the melt waters of such glaciers. In consequence the raised beach platforms provide a wide variety of local environments dependent on their elevation and composition. Many are sandy, not only as a result of their original formation but due to the later movement of blown sand over compacted 'Atlantic' surfaces—producing thereby frequently a whole suite of fossil soils and humus horizons. In some localities shell sand improves the agricultural potential of the soil, in others the sand becomes waterlogged or iron pan forms, rendering the ground difficult to cultivate. Elsewhere light pebbly loams have developed on the marine sediments of the beaches, reinforced by downwash of material from the steep slopes behind, or the raised beaches consist merely of pebble banks with a thin soil cover, or rocky wave-cut platforms. Their disposition also varies. Sometimes they are narrow, isolated ledges hemmed in by high, bleak moorlands and offer only precarious footholds to man and his farmstock ; sometimes broad continuous terraces capable of supporting a string of homesteads. Here they are well-drained, there ill-drained and fit only for poor pasture. Thus the term 'raised beach' has no single environmental connotation and until a much-needed and long-overdue survey is made of these characteristic Scottish coastal forms in their ecological totality it is dangerous to generalise on their value to prehistoric farming communities.

For example, in a paper published in this magazine over twenty years ago, Childe suggested [32] that the earliest farmland of the western settlers comprised " raised beach platforms or alluvial gravels adjacent to convenient landing places " with their family tombs " on the slopes immediately adjacent thereto " and referred in particular to conditions in Bute, Kintyre and Arran in support of this hypothesis. This contention has been challenged in more recent papers by Margaret Davies and Worth, with particular reference to Arran. The former notes that within the Clyde Province most of the tombs with crescentic façades are situated on relatively high rocky outcrops, sometimes well inland such as those of Carnbaan and Baile Meadhonach in Arran, while the " later gallery graves without façades " are found on the raised beaches, and concludes that " the primary settlers of the Clyde provinces were interested in hill pastures and stone for trade, and that they were followed by later peoples who realised more clearly the agricultural value of the raised beaches ".[33] Worth,[34] also, while accepting Childe's chronological distinction of façaded and non-façaded tombs disagrees with his generalisation on their setting, finding only two of the " primary megalithic tombs " of Arran in reasonable proximity to extensive raised beaches—namely the Monamore site on a ledge at 400 feet O.D. overlooking the wide raised beaches of Lamlash Bay, and the site a short distance from the mouth of the Sliddery Water ; whereas, he points out, the Machrie lowlands, comprising " the finest development of raised beach and alluvial flats in the whole island " boasts no such early tombs, achieving importance only in a later phase of colonisation.

Accepting the fact that in the absence of actual domestic sites the chambered tombs are at most only tentative indicators of tracts of

occupation, such geographical controversy is complicated, however, by doubts concerning the archaeological validity of assuming that façaded tombs are appreciably earlier than ' degenerate ' non-façaded tombs in Western Scotland. At Cairnholy, for example, there are two tombs within 500 yards of each other—one with a fine façade and forecourt, the other lacking such features—and yet, as excavation has shown, approximately contemporary. Indeed, as Piggott has suggested,[35] it may well be that the crescentic façades of Clyde-Carlingford tombs were the result of local, regional development of funerary ritual. Certainly the non-façaded tombs have produced some very early types of pottery for them to be regarded as a ' late degeneration series '. The higher, inland and more elaborate sites in Arran in this context could therefore represent the growing power and cultural evolution of coastal farming communities. Alternatively the two types of tomb may indicate the presence of two different strains of settlers in the initial colonisation. One must conclude then that until more accurate chronological evidence is available discussions of local shifts in geographical values are premature.

On the other hand, difficulties in detailed interpretation do not necessarily preclude statements of a general character relative to the distribution as a whole, that is from a macroscopic point of view. As such it exhibits several striking features. The individual tracts of occupation vary considerably, whether they be sands and gravels of the western lowlands of the Outer Isles, outwash deposits at the foot of the hills in South-west Scotland, or weathered drift by sheltered bays and inner channels of the Orkneys, but the majority are located in close proximity to the sea. Maritime values as well as agricultural values appear to be involved. It is thus unfortunate that so little is known of contemporary boat construction, and navigational capabilities. It is probably safe to assume that some form of dug-out canoe was used for river work and sheltered sea passages, since these are attested from earlier deposits such as the carse clays of the Forth, even though none have been found so far in a definitely Neolithic context in Scotland. But it is doubtful whether only canoes could have been used for some of the longer voyages implied by the nature of the megalithic distribution. Lindsay Scott one feels was probably correct in surmising that a colonising people who introduced the chambered tombs and other things of Mediterranean affinities could hardly have failed to use some type of sea-going craft related to vessels of that region.[36] Possibly they were carvel-built craft with stitched hulls and projecting keels, propelled by oars or paddles and subsidiary square sails. Their affinities might well be sought among the various vessels depicted in Minoan art, particularly as the spiral motif common in Irish and Scottish art at this period is also found in Crete in Middle Minoan times (2000-1700 B.C.), or among the ancient boat forms which have survived on the Portuguese coast.[37] With such vessels quite long trading voyages would be possible in the summer months, when gales were few and long hours of daylight in northern latitudes allowed the navigators to work along channels sheltered by the natural breakwaters of the islands and peninsulas of the broken west coast.

For primitive craft unable to sail close to the wind the west coast has many advantages in this respect over the east coast. Its irregularity, for example, far from being an obstacle allows longer voyages to be broken down into stages, utilising beaching points, islands, and sheltered stretches of water, to wait for favourable conditions of wind and tide (see Fig. 5). It also allows in many instances the selection of alternative routes if conditions are adverse, in a way that the east coast does not. Furthermore, for summer sailing, southerly winds in early summer and northerly winds in autumn are prevalent enough to allow considerable distances to be covered northward and yet secure return voyages before the winter gales set in. Indeed, mariners with Mediterranean traditions would be much more at home with west coast conditions than they would be with the east—a factor which is often ignored when explanations of the failure of megalithic seafarers to penetrate northward along the eastern seaboard of Britain are couched only in terms of the difficult passage of the Straits of Dover. Of course this west coast characteristic of familiarity is not confined only to the maritime activities of the early farming communities, but appears to have influenced their choice of agricultural land also. Morphologically, even if not climatically, there are a number of ' Mediterraneans ' along the Atlantic seaboard of Britain, where mountainous backing to raised beaches, enclosed and island-studded sea-spaces, recall conditions in that southern sea where in Plato's time human communities gathered " like frogs around a pool ".

Regionalism

With this in mind we may now attempt to assess the regionalism exhibited by this primary agricultural colonisation of Scotland, clarifying first the type of regional unit we seek to establish.

While areal differentiation is as vital to a chorographic study such as geography as periodic differentiation is to a chronological study such as archaeology, it is difficult to accept the proposition frequently made that these two attitudes towards reality are mutually exclusive.[38] Geographers may attempt to minimise the element of time by concentrating on the present landscape or subjecting a past landscape at a cross-section in time to geographical analysis. Archaeologists may attempt to minimise the element of space by concentrating on the evolution of cultures as entities growing in time regardless of location. Neither would pretend, however, that such studies in themselves present a complete or even true picture of reality in its four-dimensional aspect of a space-time continuum. Incompleteness may be accepted as an unavoidable consequence of the modern division of labour in scientific observation, but when this leads to error in interpretation artificial academic barriers of methodology tend to be breached. Geographers come to realise that regional unities they have been accustomed to regard as environmentally determined and eternally applicable are in fact often expressions of a cultural epoch and quite narrowly time-bounded, while archaeologists recognise that many features they once regarded as belonging to particular stages or periods of cultural growth, and as such widely separated in time, are really

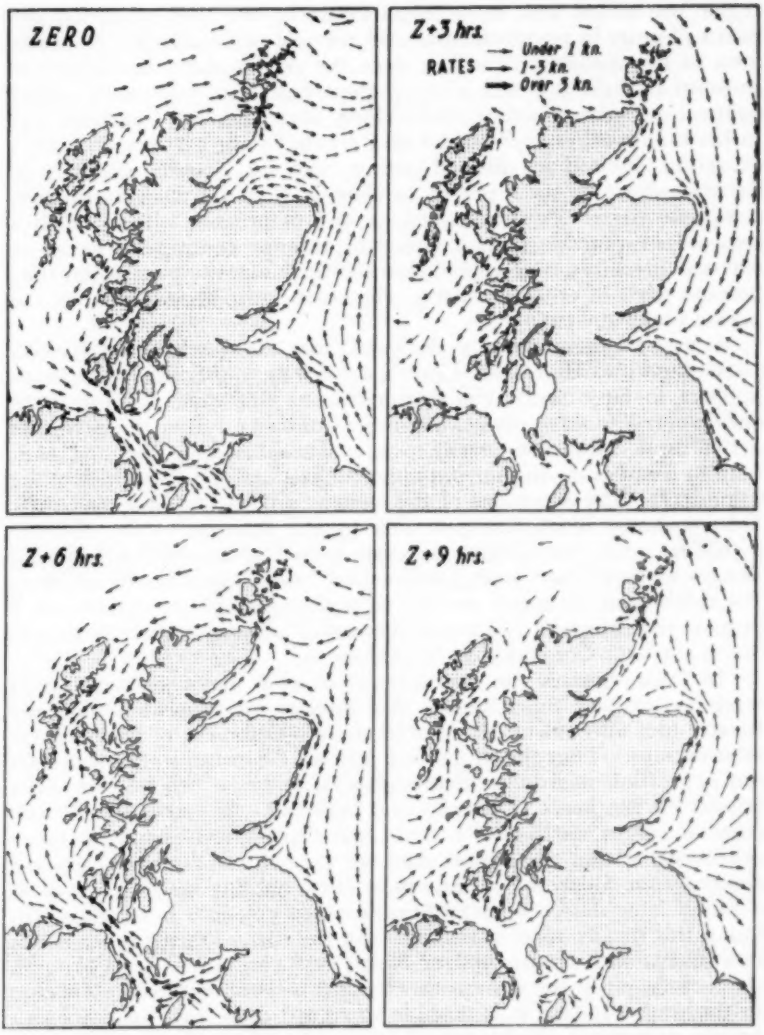

Fig. 5. Direction and force of Tidal Streams round Scottish coasts during 12-hour period. (*Based on Atlas of Tides and Tidal Streams. Admiralty, 1946.*) *Zero* coincides with time of maximum southerly flow through North Channel. No great changes in this pattern are likely to have occurred during the last 4000 years.

contemporary expressions of areal differentiation. In consequence students of both disciplines have moved still closer together in recent times in their common quest for the *genius loci*, and as a geographer one must pay tribute to the geographical insight and ' eye for country ' that has become such an outstanding characteristic of the present generation of British archaeologists. In this context then the type of

region one would wish to establish would be one that contained elements of unity in environmental and cultural relationships. No static form of regionalism will suffice since the relationships are subject to constant change, nor will a regionalism based on uniformity, either cultural or environmental, since along that path lies fragmentation rather than synthesis. What we seek are, in Strabo's words, " theatres of action, limited for limited action, vast for grander deeds ", or *Gestalten* whose patterns persist in spite of material changes in their composite parts. In other words unities of process, within which a regional structure is formed either by interior centropetal forces or external pressures, and which preserve their identity even when they become parts of greater wholes. Can such units be identified in the period under review ?

It may be pointed out at the outset that the conventional division of Scotland into Highlands, Central Lowlands, and Southern Uplands appears to have much less significance at this time. As we have endeavoured to show above, the major contrasts during the period of agricultural colonisation seem to have been between west and east, both in terms of environmental opportunities and the behaviour of the colonists.[39] The allegiance of the western settlers lay with, and their *Lebensraum* was ultimately governed by, the seaways of the Atlantic seaboard, while the eastern colonists looked southward to Lowland Britain and eastward to the continental coasts across the North Sea. For this reason, basically one of orientation though not entirely so, I propose to distinguish two major theatres of action—namely ATLANTIC SCOTLAND and CONTINENTAL SCOTLAND.

In both theatres the introduction of new major cultural forces tends to produce repercussions and interior adjustments within the theatre first affected rather than in the establishment of inter-theatre relationships. Thus the megalithic culture, for example, worked itself out in relation to Atlantic Scotland with, as far as can be seen, little impact on the heart of Continental Scotland. It was easier for the colonial surges starting with the Clyde-Carlingford people to move northward within the region than for the settlers to move eastward across Drum Alban into what was in effect another world ; just as at a much later date sea-borne Scandinavian colonists from the north found this theatre more attractive than the east. On the other hand, movements with continental or North Sea associations tend to work themselves out in the eastern theatre and weaken in their approaches to the west. Indeed it is possible to regard these two basic Scottish regions as parts of much wider theatres of action, reflecting a general process whereby European continentality drives outwards to, but is contained by, the maritime Atlantic rim of the continent—a concept which expresses in another form Fox's distinction between Highland and Lowland Britain.[40]

As in most regional divisions, however, the recognition of regional entities does not necessarily mean that they can be precisely bounded either on the ground or by lines on a map. There are few lines in nature or culture ; with the result that most boundaries tend to be compromises—the main criterion governing their selection being

Fig. 6. Operative Regions during the primary agricultural colonisation of Scotland. Arrows denote the main routes or zones of inter-regional contact.

simply their relative power to divide. Thus in Figure 6 watersheds have been chosen as the main regional boundaries not because the rather ill-defined nature of Drum Alban, for example, can be entirely represented by a line, but that during a period in which movement by

water seems to have been more significant than movement by land and pioneering activity appears to have expanded from the seaboard inland, water divides represent in the most powerful way the interior barriers to inter-regional contacts by sea-borne colonists. It is no accident that the phrase " across the great Divide " has become associated with the colonial activities of seafaring communities. In such circumstances water unites and watersheds divide.

Contact zones between Atlantic and North Sea drainage basins during the period under discussion appear from the distributional maps to have been very limited. As Lindsay Scott has shown,[41] apart from the possible use of the Biggar Gap between the Clyde and Tweed basins, and canoe portages to the north-east of Loch Lomond, the main trans-peninsular corridors lay in the north, particularly that provided by the narrow, lake-studded gash of the Great Glen. Once the latter had largely replaced the more hazardous journey round Cape Wrath it provided the main through-route from the west to the North Sea coastlands—a function it was to maintain for many centuries to come. At this time it was followed by the northward-moving megalithic culture-bearers to such an extent that a strong case can be made out for including the shorelands of the Moray Firth into which they spread with Atlantic Scotland in this respect. The individuality of the tomb structures in the Moray Firth area, such as the Camster type of round cairn and long ' horned ' Yarrows type as described by Piggott,[42] argue in favour of its being regarded as a region in its own right, however, and this is supported by its ability to react independently and change allegiances in response to eastern influences in a later phase of the colonisation. A parallel case is provided by the area centring on the Orkneys and north coasts of Caithness and Sutherland. It is perhaps more clearly part of Atlantic Scotland both from an environmental and cultural point of view, receiving influences by the western seaways as well as by the Great Glen. Nevertheless its regional individuality is expressed in its own unique cultural assemblage, including the Maes Howe type of round cairn, survivals of ancient northern forms of equipment, and the products of eastern and western cultural convergence.

This characteristic of convergence is of course facilitated by the peninsularity of Northern Scotland and is a feature of most of the northern regions, to a greater or lesser degree. The Orkneys and Caithness show it in abundance, and so does the north-eastward projecting ' knuckle ' of Aberdeenshire, with the Moray Firth ' funnel ' distributing western influences to the north-east and south-east, and then later concentrating westwards the flow of continental influences. Contacts within this north-eastern trio of regions are facilitated by the Strathnaver-Helmsdale, and Thurso-Wick trans-promontory routes in the north, and the Deveron-Ythan corridor in the south, which obviate the sea hazards of the Pentland Firth and the exposed coasts of Northern Aberdeenshire respectively. The tidal streams which affect navigation round the two promontories culminating in Duncansby Head and Kinnairds Head are shown on Figure 5, and these two handicaps to coastal navigation have been used as control points in the regional delineation suggested on Figure 6.

Sea conditions must obviously be taken into account also in the delineation of those regions which in fuller measure comprise the Atlantic theatre of action. Here sea regions or 'mediterraneans' in the sense we have indicated earlier are the operative units. To overseas immigrants on a foreign coast the sea represented a link with what was accomplished and known, and forged the bonds which drew human communities together in common destinies, whereas the land constituted a frontier, physical and perceptual, stretching steeply upwards to the interior watersheds. The reality and function of an Irish Sea Region, embracing parts of the seaboard of South-west Scotland have been admirably demonstrated by Margaret Davies, and at times the North Channel coastlands undoubtedly formed part of this larger entity; but the role of the latter as the hearthland of the Clyde-Carlingford culture, the cross-channel relationships mentioned above, and its personality as a sea-corridor of individual maritime characteristics all serve to foster its regional identity. As becomes a sea region of this nature, islands appear to have played an important part in its internal settlement structure, with Arran and Bute as central concentration points, but its outer bounds are not easily defined. In the south the strong tidal races between the Mull of Galloway and the Irish coast appear to have constituted a sufficiently powerful navigational hazard to divert some inter-regional movement to the Stranraer isthmus between Luce Bay and Loch Ryan, and to passes across the Galloway watershed, so that in terms of difficulty of movement a divide such as shown in Figure 6 would provide a reasonable frontier toward the sea areas around the Isle of Man. The northern frontier proves still more difficult to place. Beyond it lies another sea region —an island world of full Atlantic stature centring on Skye and the Minch, with its own environmental potentialities and cultural individuality, expressed among other things by the development of circular Hebridean passage graves. The latter are found from Lewis to Lorne where North Channel cultural forms are encountered, and at this cultural junction point there occur the vital interior channels leading from the Crinan isthmus and Sound of Jura, through the islands of the Firth of Lorne, to the parting of the ways northward represented by Loch Linnhe and the Sound of Mull. The former leads north-eastward to the Great Glen and another world beyond, the latter north-westward to the heart of the Hebridean sea region. It would seem reasonable to choose this strategic, physical, and cultural cross-roads as the inner pivot of a boundary between the North Channel and Hebridean Regions. Its outer limb will obviously swing considerably from a cultural point of view in sympathy with the vigour of sea-movements, particularly from the south; at times indeed reaching up to the southern parts of the Long Island, as during the northward expansion of the Clyde-Carlingford people. Under less vigorous influences however, it appears to conform more closely to the alignment shown in Figure 6—provided physically by the natural breakwater of Jura and Islay, and the rim of the North Channel running across the gateway of the Atlantic to Malin Head in Northern Ireland. Indeed the difficulty experienced in drawing boundaries across the western sea-

ways is in itself a cogent indication of the reality of the larger whole constituted by Atlantic Scotland.

Similar problems are encountered in the delineation of regions within the theatre of action I have designated ' Continental Scotland '. Here, too, as we have seen, the main direction of cultural movement was northward in the early phases of agricultural colonisation with origins in Yorkshire and northerly outposts on the coastlands of the Moray Firth, and in a similar manner it is possible to recognise cultural differences between the extremities of such movements. In the southern seaboard area the cultural character of the mixed food-producing and food-gathering communities of Berwickshire appears to be closely linked with that of North-east England, and although it may be eventually possible with more evidence to distinguish a Tweed Valley region, at present it is probably safer to regard it as part of the larger Northumbrian Region with a northern frontier along the Moorfoot-Lammermuir divide overlooking the Forth Lowlands and coming down to the sea about St Abb's Head. In the north, however, beyond the Mounth Divide and the Stonehaven gate, Aberdeenshire was developing a strong individuality at this time as a result of the already-mentioned convergence of western and south-eastern influences, and the momentum of earlier cultures based on its extensive hunting terrains and the greatest flint supplies in Scotland. In between extended the lowland gulf of the Tay-Forth region, with scattered farming communities occupying the drier coastal sites and mid-slopes overlooking the wet estuarine lowlands. It was by no means the great corridor of west-east movement it was to become in later times, although some pottery finds on the south bank of the Forth between Falkirk and Dunbar are considered by Lindsay Scott to indicate western connections, and large areas appear to have been negative as far as agricultural settlement was concerned. This threefold pattern of spatial differentiation is confirmed in its main lineaments by the selective colonisation of the Beaker folk as shown in Figure 4. The striking concentration of beakers in Aberdeenshire recalls the earlier concentration there of carved stone balls as described by Childe,[43] and has affinities with the other concentration in South-east Scotland and the Northumbrian region.

In conclusion, then, it will be seen that eight regions have been differentiated under this system. Based as they are on limited data and a greater measure of subjective judgement than one would wish, it would be surprising if the scheme met with universal approval in all its details, but the writer believes that its major outlines are in accordance with the review of the agricultural colonists and environmental influences which preceded it. At least it provides a basis for further examination of a subject of concern to both geographers and archaeologists. Indeed it has been my aim throughout this essay to demonstrate the inter-relationships which exist between these two disciplines in their respective interpretations of landscape, and in particular to highlight the problems posed to students of the geography of Scotland by the material unearthed by archaeologists in recent years.

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[3] Evans, E. E. Lyles Hill—a prehistoric site in Co. Antrim. *Belfast Museum Quart. Notes,* 1940, LXIV.

[4] Marshall, J. N. Archaeological Notes. *Trans. Bute. Nat. Hist. Soc.,* 1930, 50-54.

[5] For description of tombs see e.g. Bryce, T. H. The Cairns of Arran. *Proc. Soc. Ant. Scot.* 1901-2, XXXVI : 74-181 ; 1902-3, XXXVII : 36-67 ; 1908-9, XLIII : 337-370 ; also Cairns and Tumuli of Bute. *Proc. Soc. Ant, Scot.,* 1903-4, XXXVIII : 17-81 ; Piggott, S., *op. cit.,* Chaps. V and VI ; Piggott, S., and Powell, T. G. E., *op. cit.* ; and for general background, Glyn E. Daniel. *The Prehistoric Chamber Tombs of England and Wales.* Cambridge, 1950.

[6] Piggott, S. *Op. cit.*

[7] The dangers of using tomb morphology for detailed analysis of origins, however, are summarised by L. S(cott) in a review of Glyn E. Daniel, *op. cit.,* in *Antiquity,* 1951, XXV : 37-39.

[8] Piggott, S. *Op. cit.,* p. 29.

[9] See Jessen, K., and Helbaek, H. Cereals in Great Britain and Ireland in Prehistoric and Early Historic times. *Det Kong. Danske Videns, Selskab. Biolog. Skrifter,* 1944-5, III (2), p. 18. The identifications of grain made in this authoritative work largely supersede those mentioned in Kilbride-Jones, H. E., and Mitchell, M. E. C. Primitive Agriculture in Scotland. *Proc. Soc. Ant. Scot,* 1932-3, LXVII : 70-81.

[10] For general discussion of contemporary flint working see Lacaille, A. D., *op. cit.* Chap. VIII.

[11] The limitations of inferences made from prehistoric material are well summarised by Smith, M. A. The Limitations of Inference in Archaeology. *Arch. News Letter,* 1955, V (1). But it may be suggested that in general economic inferences tend to be safer than social inferences.

[12] Piggott, S., *op. cit.,* distinguishes four main groups, viz. (1) Hebrides, (2) Orkney-Cromarty, (3) Shetland, and (4) Clava, each marked by distinctive tomb types. See also Childe, V. G. *Scotland before the Scots.* London, 1946, Appendix I ; and Scott, W. L. The Neolithic culture of the Hebrides. *Antiquity,* 1942, XVI : 301-6.

[13] Childe, V. Gordon. *Skara Brae.* London, 1931.

[14] See Childe, V. Gordon. A Stone Age settlement at the Braes of Rinyo, Rousay, Orkney. (First Report) *Proc. Soc. Ant. Scot,* 1938-9, LXXIII : 6-31 ; (Second Report) *Proc. Soc. Ant. Scot,* 1947-8, LXXXI : 16-42.

[15] *Skara Brae,* pp. 179-180.

[16] Gjessing, G. *The Circum-polar Stone Age.* Copenhagen, 1944, and in *Antiquity,* 1953, XXVII : 131-136.

[17] See Warren, S. H., *et alia.* Archaeology of the submerged land surface of the Essex Coast. *Proc. Prehist. Soc.,* 1936, II : 178-210. It has been suggested that this transgression may be the equivalent of L. G. IV (Fourth Litorina max.) of Scandinavian chronology.

[18] Piggott, S., *op. cit.,* p. 344.

[19] See e.g. Callander, J. G. Scottish Neolithic Pottery. *Proc. Soc. Ant. Scot.,* 1928-9, LXIII : 29-98 ; and Prehistoric Archaeology in the North-east of Scotland. *The Deeside Field,* 1935, No. 7. Childe, V. G. The early colonisation of North-eastern Scotland. *Proc. Roy. Soc. Edin.,* 1929-30, 50 : 51-78 ; and Atkinson, R. J. C. Fisherman and Farmers, in Report of the Fourth Scottish Summer School of Arch. *Arch. News Letter,* 1955, 6 : 12-19.

[20] Piggott, S. A note on the relative chronology of the English Long Barrows. *Proc. Prehist. Soc.,* 1935, I, fig. 7, p. 124.

[21] Jessen, K., and Helbaek, H., *op. cit.*, p. 18.

[22] See e.g. Mitchell, M. E. C. A New analysis of the Early Bronze Age Beaker Pottery of Scotland. *Proc. Soc. Ant. Scot*, 1933-4, LXVIII : 132-189 ; and Scott, W. L. The colonisation of Scotland in the Second Millenium B.C. *Proc. Prehist. Soc.*, 1951, XVII : 16-82.

[23] See e.g. Godwin, H. *The History of the British Flora.* Cambridge, 1956. Matthews, J. R. *Origin and Distribution of the British Flora.* London, 1955. Ritchie, J. *The Influence of Man on Animal Life in Scotland.—A Study in Faunal Evolution.* Cambridge, 1920. Movius, H. L. *The Irish Stone Age.* Cambridge, 1942, Chap. III and Appends. V and VI ; and the opening chapters of Lacaille, A. D. *The Stone Age in Scotland.* London, 1954.

[24] Scotland contributed much to the pioneering of Quaternary Studies in the work of men such as Jamieson, Geikie, and Lewis. Most of the recent work in this field has been carried out under stimulus from Scandinavian, Irish, English (Cambridge and London) and French schools of Quaternary Research.

[25] Lewis, F. J. The Plant Remains in the Scottish peat mosses. *Trans. Roy. Soc. Edin.*, 1905-11, 41, 45, 46, 47. [26] Godwin, J. *Op. cit.*

[27] Iversen, J. Landnam i Danmarks Stenalder. En pollenanalytisk Undersøgelse over det første Landbrugs Indvirkning paa Vegetationsudviklingen. *Danm. geol. Unders.*, 1941, II (66) ; also Pollen Statistical evidence and experimental checks on Neolithic forest clearance. *Arch. News Letter*, 1954, V (1).

[28] E.g. *Plantago lanceolata* (ribwort) and *P. media* (hoary plantain). At the same time cereal pollen may occur, a charcoal layer can often be recognised, non-arboreal pollen increases at the expense of arboreal pollen, and among the tree colonists of clearings, birch, alder and hazel frequencies increase.

[29] Cf. Childe, V. G. *Prehistoric Migrations in Europe.* Oslo, 1950. Chap. V ; and Clark, J. G. D. Farmers and Forests in Neolithic Europe. *Antiquity*, 1945, XIX : 57-71.

[30] See e.g. Scott, W. L. The Chambered Tomb of Unival, N. Uist. *Proc. Soc. Ant. Scot.*, 1947-8, LXXXII, p. 1.

[31] General descriptions can be found in Steers, J. A. *The Sea Coast.* London, 1953 ; Lacaille, A. D., *op. cit.* ; and Movius, H. L., *op. cit.*

[32] Childe, V. G. Neolithic Settlement in the West of Scotland. *S.G.M.*, 1934, L., p. 22.

[33] Davies, Margaret. The Diffusion and Distribution Pattern of the Megalithic Monuments of the Irish Sea and North Channel coastlands. *Ant. Journ.*, 1946, XXVI, p. 53.

[34] Worth, D. H. A Note on the physical setting of the prehistoric monuments in Arran. *Geographical Studies*, 1955, 2 (1), 53-57. [35] Piggott, S. *Op. cit.*, 1934, p. 187.

[36] Scott, W. Lindsay. Colonisation of Scotland . . . *Proc. Prehist. Soc.*, 1951, XVII, p. 30.

[37] See e.g. Zervos, Christian. *L'art de la Crete. Neolithique et Minoenne.* Paris, 1956. Plates 62, 141, 142, 306 ; and Guthrie, J. Bizarre craft of Portugal. *Mariners' Mirror*, 1949, 35 : 166-181. Cf. Lethbridge, T. C., *Herdsmen and Hermits.* Cambridge, 1950.

[38] See e.g. The discussion in Hartshorne R. The Nature of Geography. *An. Assoc. Amer. Geog.*, 1939. XXIX, p. 360 *et seq.* I have discussed this problem at length in Kirk, W. Historical Geography and the Concept of the Behavioural Environment. *Indian Geogr. Jour. Silver Jubilee Vol.*, 1951 : 152-160.

[39] Cf. Fairhurst, H. The Geography of Scotland in Prehistoric Times. *Trans. Glasgow Arch Soc.*, 1954, XIII, fig. 2, for a similar distinction between East and West in the Early Iron Age.

[40] Fox, C. *The Personality of Britain.* 3rd Edit. Cardiff, 1938.

[41] Scott, W. Lindsay. *Op. cit.* Part 2. [42] Piggott, S. *Op. cit.*, p. 234 *et seq.*

[43] Childe, V. G. The Early Colonisation of North-eastern Scotland. *Proc. Roy. Soc.* Edin., 1929-30, 50, p. 73.

THE CAIRNGORM FLOODS, 1956

SUMMER SOLIFLUCTION AND DISTRIBUTARY FORMATION

P. D. Baird and W. V. Lewis

In recent years many striking examples of flood erosion and deposition have occurred in Britain. The disastrous Lynmouth floods [1] were characterised mainly by damage in the narrow river channels, but several debris slides scarred the steeper slopes on the higher ground. Deposition in the form of stone deltas marked some lesser floods in the Barmouth-Dolgelly area [2] and there were "cloudbursts" in the Chilterns,[3] and near Weymouth.[4] More widespread effects resulted from floods in the Ben Nevis area in May 1953. Common [5] very clearly demonstrated that the dominant effects of these floods were long slide tracks starting in round-headed land-slip scars at elevations of 1,000 to 1,800 feet and ending in substantial debris fans at the foot of the slopes almost at sea level. These are excellent examples of solifluction phenomena normally associated with periglacial conditions. The Cairngorm floods of August 1956 produced fine examples of these same solifluction features on the steep hillsides and, in addition, caused marked stream erosion and deposition on the flat valley floors.

The sequence of storms leading up to the August floods may well have prepared the ground for the final spectacular results, since the summer of 1956 will be remembered as a dismal one in contrast to that of 1955, when the Cairngorms enjoyed many weeks of fine hot weather and temperatures rose to 65° F. on the summit of Ben Macdhui and 85° F. in Braemar. August 1956 was particularly cool and cloudy, although the total rainfall was not startlingly great. Two earlier storms had already occurred. The first was on the 11th of June when, after a warm calm spell, a heavy thunderstorm developed and the full fury of its rain-and-hail-fall descended on the northern slopes of Cairn Lochan, Cairngorm and the region around Glenmore Lodge. Over three inches of precipitation caused flooding which washed out foot-bridges, choked the lodge water supply and scarred the hillsides in this locality. One of the authors (P.D.B.) was climbing Ben Macdhui from the south on this day and anxiously observed the storm moving from the Garbh Choire of Braeriach in a north-easterly direction.

On the 28th, 29th and 30th of July another very heavy rainfall occurred in north-east Scotland. This was the storm that caused severe flooding in the Inverness-Nairn-Forres region. Nearly 5 inches of rain fell in the headwater areas of the rivers here. Dyce (Aberdeen) recorded 3·5 inches in the three-day period. At Luibeg in the southern Cairngorms only 1·75 inches of rain was recorded, yet the Derry Burn rose sufficiently to carry away the footbridge one and a half miles north of Derry Lodge. But the most destructive storm of this disastrous summer was yet to come. On the 13th of August a deep depression (978 mb) moved over the Cairngorms and was centred there at about noon. At the same time the air was extremely moist ; at Stornoway

it was saturated to 24,000 feet and there was severe convective instability to at least 10,000 feet. Rain began falling at Luibeg on the 12th, when 0·50 inches fell ; it increased on the 13th and was accompanied by high winds. The anemometer on Ben Macdhui recorded an average wind of 30 m.p.h. from 4 a.m. to noon on the 13th of August, followed by a comparative lull as the centre of the low passed and then increased to an average of 27·5 m.p.h. for the 24 hours until 8 p.m. on the 14th.

On the 13th, 3·37 inches of rain were recorded at the new Luibeg rain gauge. The old rain gauge, much more exposed, gave an inch less, a good example of the unreliability of this, our simplest meteorological instrument, under conditions of high wind in open country. Next day, the 14th, a further 0·35 inches fell at Luibeg, making a total of 4·32 for three days. At the same period only 1 inch was recorded at Aberdeen (Dyce), but it seems likely that maxima of over 6 inches fell in the two glens, Glen Geusachan and Allt Carn a' Mhaim (Fig. 1). During the night of the 13th-14th of August, the stalker and his wife at Luibeg had a sleepless night as they listened in the dark and lashing rain to the increasing roar of the river and the tumble of the banks. It rose to within a vertical foot of their dwelling, and removed the footbridge which connected them with the road to the valley. Further upstream the Parker Memorial Footbridge erected over the Luibeg was carried 100 yards downstream and its supporting masonry piers overturned. The stream bed at the bridge span had more than tripled its previous width.

Glen Derry appears to have received less heavy precipitation, but there was enough for the burn to burst its banks on the flat north of Derry Lodge and to carve a new channel to the west, toppling two pine trees in the process. After a lapse of six weeks it still had not settled into a definite course, but rivulets were spilling all over this flat area.

Lower down the Lui the Black Bridge which carries the roadway was damaged, but not destroyed. Its centre pier, undercut by the torrent, settled about six inches to a foot and moved a similar distance downstream. Still further downstream the Lui and the Dee join. As the headwaters of both had received excessive precipitation, the united stream surged past and over the ' Canadian ' bridge above Inverey. This log truss bridge with a central crib had been erected in 1941 by the Canadian Forestry Corps and had recently been given a redecking by the Mar Estate. Despite the fact that the water level was up to two feet *above* the deck the bridge held, but the boulder and gravel fill at each approach was washed out to bedrock leaving it impassable to wheeled transport. Below Inverey, the flood dissipated rapidly, and although some flooding occurred near Braemar it was not of sensational proportions. This stresses again the extremely local character of the storm.

The most obvious result of the August flood was the scarring of the hillsides, not with torrent tracks, but with solifluction tracks and tongues ; the stream channels within the tracks were subsidiary affairs although the resulting deltas or fans on the valley floors were often

relatively large. Had the winter season intervened between the floods and our visit we might well have attributed the scars to the period of snow melt and of the lessening of winter's grip on the frozen ground. But, like those on Ben Nevis, they were definitely formed in summer.

The southern slopes of Glen Geusachan are covered by a layer of boulder clay in places thirty to forty feet thick, and this mantle was cut clean through to bedrock at several points (Plate 2a). The whole valley side was corrugated with V-sectioned ravines mostly ten to thirty feet deep, and of various ages, so the results we examined were probably only a somewhat more extreme form of those which may

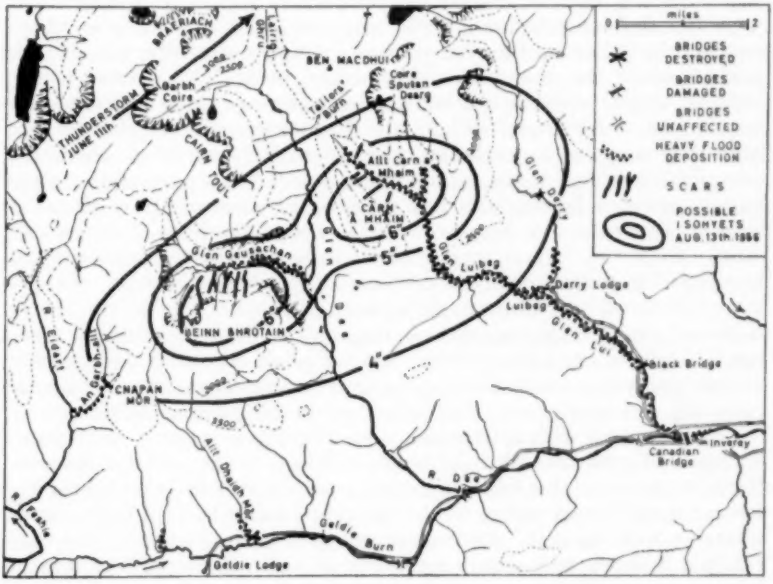

Fig. 1. Location map showing storm of 12-14th August 1956.

occur several times a century. The fresh scars were erratically distributed along the side of the valley and resulted presumably not so much from the rainfall distribution as from the local instability of the boulder clay and soil slopes. The scars were very long and narrow when compared with those of the Exmoor floods of 1953, or with those formed earlier in the lake deposits on the steep sides of Glen Roy north of Ben Nevis. Nor had these Cairngorm examples the characteristic miniature cirque-like shape at their sources so well exhibited in land slips. Most of them remained narrow right to their heads, but two or three examples of very localised rounding did occur at the heads. Many extended right to the crest of the slopes of Beinn Bhrotain, 1,500 feet above the floor of Glen Geusachan. Others began at the upper limits of the boulder clay, where this gave place to the lightly vegetated scree and rock slopes near the crest. Few, if any, were

entirely new scars, though some had been lengthened and all greatly deepened, as was revealed by shreds of vegetation still in place perhaps half-way down the sides of the little ravines.

The most characteristic feature of solifluction tracks—the parallel bounding walls of large stones and boulders—was very well shown. Where the valley-side slopes became gentler and incision was at least partly replaced by deposition these boulder walls rose as much as three feet above the absolutely clean heather and marshy grass on the outside, and nearly as much above the mixture of stones and gravel, with a small clay fraction, that lay within the bounding walls (Plate 2b). The very few signs of muddy deposits, or of flattening of vegetation by water flow outside these walls, suggested that the first and major onset of the valleyward movement was a simple solifluction tongue that pushed aside the major boulders—often three feet across—as the bulging tongue with its quicker-moving centre of finer material continued down the slope. Where the bounding walls were three feet high they were, at a maximum, twenty yards apart, from which the size of the moving tongue can be appreciated. This particular tongue had subdivided leaving the two inner walls converging up slope to form a prow fully five feet above the surrounding chaos of stones and sand. Even this largest tongue had barely reached the main stream but ended in a flattish spread perhaps half an acre in extent. Everywhere material was surprisingly coarse, boulders a foot to six feet in diameter being frequent, though digging, as usual, revealed a finer fraction below. Anything below the sand grade appeared almost solely as little finger deltas which had spread out fanwise from the main tongue probably as a secondary effect following the initial main advance.

As is normal with solifluction under spring snow-melt conditions, a stream of gradually clearing water followed in the wake of the solifluction tongue. This had cut a ravine several feet deep both into the steeper upper slopes where the boulder clay was thin, and lower down where it was thickest. In several places this final channelling had reached bedrock and revealed the flat slab-like surface of the underlying granite. These streams had mostly lost themselves in the final solifluction tongue although a considerable volume of water, if not of debris load, must have reached the main stream. Where the meandering main stream swung across the valley near the foot of these corrugated slopes a much larger proportion of the soliflucted material had reached it and been carried away. But the impression was nevertheless left on our minds that a major part of the river's load was obtained from its own immediate banks, because the widening of these flood beds was fully as spectacular as the long solifluction trenches which scarred the extensive valley sides.

The northern and eastern slopes of Carn a' Mhaim which had likewise, though less generously, been plastered with boulder clay, were similarly corrugated with old and fresh solifluction tracks, in particular the section of the slopes which face due north. Some of these long trenches, like those in Glen Geusachan, were barely fifty yards apart.

A particularly well-developed trench occurred on the north-east

side of the glen coming from midway up the Ben Macdhui slope. Its deposition tongue on the flat valley floor (it did not reach the stream bed) resembled a new road-bed dumped by a bulldozer on the heath. The Allt a' Mhaim itself had exposed many fresh sections of boulder clay and bedrock in its banks and at the junction with the burn from Coire Sputan Dearg had broken several new channels, two of which were still flowing over two-foot waterfalls after the lapse of over two months.

In contrast with the solifluction features of the steep side-slopes of the upper valleys, were the features typical of river floods exhibited in the main channels a mile or so downstream. The freshness of the banks of sand, gravel, stones and boulders which divided and sub-divided the stream channels, the very substantial bank erosion—at several points the Luibeg had trebled its flood channel width overnight—led us to ponder the little understood problem of the development of distributary patterns. One of the authors (W.V.L.) has, from time to time, studied this matter in places as contrasting in scale and environment as the Physiographical Laboratory at Cambridge, the beach and marsh creeks of Scolt Head Island (by kind permission of the Nature Conservancy) and glacial outwash streams in South-east Iceland and Central Norway.

In a helpful over-simplification, Lake [6] suggested that if a river were heavily laden with fine material this would tend to be dropped at the side of the stream where the velocity was checked, as where the Mississippi reaches its delta and so the levees are built out. If, on the other hand, the load were coarse it would tend to be dropped in the middle of the stream where the higher velocity enabled the river to carry the greatest load. Many instructive points have been made by subsequent authorities both in the field of fluvial hydraulics and of geomorphology, but, so far as we are aware, the general problem of stream sub-division still awaits solution. Mackin [7] wrote that soft river banks lead to undue widening which, in turn, leads to the formation of braided channels because the latter are less inefficient than a single very wide and shallow channel. There is much truth in this terse statement. Birot [8] made the helpful suggestion that if a river on average does no erosion, during floods it widens and deepens its channel and the widening cannot be reversed during normal times. References to the formation of shoals always seem to emphasise those associated with meanders. Gilbert [9] early drew attention to the deep which formed a short distance downstream from the outside of a bend, and to the shoal which formed nearly opposite it and which continued across the stream diagonally to join the shoal on the inside of the next bend. The flood factor is introduced by Straub [10] who considers that an increase of discharge leads to scouring on the outside of the bends and to building up of the bars at crossings. At low water levels these bars form submerged dams, the finer material of which is removed and deposited in the deeps, but the coarser fraction remains as a highly resistant layer of gravel. Accordingly the river becomes a succession of pools and shoals. These meander deeps and shoals are stressed, again, in two excellent recent works on the subject by Leliavsky [11]

and by Sundborg.[12] The deeps and shoals which we examined on the Luibeg were not all associated with bends, but they too, demonstrated that local erosion or scour can be replaced almost immediately downstream by local deposition.

On the straight reaches of the Luibeg and the Geusachan streams the deposits from the August floods had accumulated again and again in the middle of the stream and had, no doubt, been amply supplied by the generous load where the mid-stream current was swiftest. But a further and probably more important feature was evident. The channel of the river was invariably scoured deepest against banks made semi-permanent by the matted roots of pine trees or heather and associated plants. As the stream usually approaches the resistant bank at an angle, meander scouring is partly involved. This hugging of the banks by deep little channels within the main stream can well be observed in the laboratory when a wandering stream meets the wooden side of the trough.[13] There the little stream almost invariably scours its deepest, and is most liable to remain. Friction against the soft sandy bank is increased by the picking up of the load—though not as

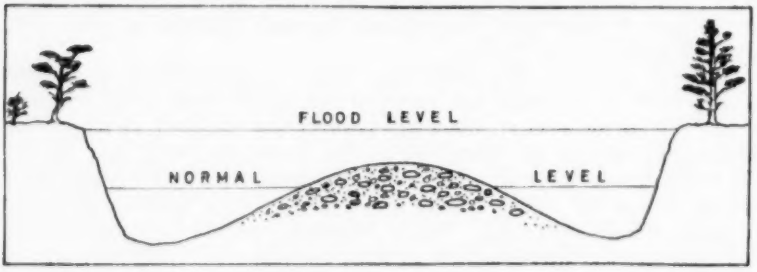

Fig. 2. Cross-section of stream channel at flood level.

spectacularly as Bagnold [14] showed in the case of air currents—as the contrast of density between air and sand is so very much greater than that between water and sand. The water can therefore accelerate forwards the sand or gravel without losing nearly as much momentum —and so velocity—as do air currents when they accelerate a solid load. The loss in the case of water is nevertheless very real. But this retardation is not nearly as great against the wooden sides of the trough, or against fairly resistant banks in nature. So the stream flows fastest and scours deepest against the resistant banks. A further agency favouring this location of the deeper channels within the flood cross section is that the maximum cross-sectional gradient with loose bed-load can rarely if ever exceed 45° and is usually much less. If the swift current attempts to scour the base of such a slope and to over-steepen it a slide occurs, and the affected side of the deep channel is shallowed. Resistant banks, on the other hand, can remain vertical or even undercut. Thus there is the constant tendency for a stream channel which is being widened during flood to exhibit a section as in Figure 2. When the flood subsides and the more normal river level is restored a central bank will tend to divide two distributaries.

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Pl. 1. GREAT CUMBRAE ISLAND, BUTE (O.S. 71. 157568)

Air View N.N.E. along the west coast of Great Cumbrae Island looking towards the mainland coast north of Largs, showing well-developed '25-foot Raised Beach' platform and associated fossil cliff behind it. The ill-drained pasture land on 'raised beach' contrasts with arable land of interior.

Pl. 2a.

(*left*) Ravine cut thirty feet through boulder clay to bed rock: on southern slopes of Glen Geusachan.

Pl. 2b.

(*below*) Solifluction tongue of coarse debris which emerged from ravine (*left*) and spread over vegetation on the gentler lower valley-side slopes.

Pl. 3. BEAKERS

From Short Stone Cist at Nether Criggie, Dunnottar, Kincardineshire.
Discovered 30th of August 1954.

The Scotsman

Pl. 4. CRAMOND BRIDGE, RIVER ALMOND

On boundary between West- and Midlothian : Constructed in 1619, subsequently restored.

Pl. 5. GLASGOW

From the south-east showing the medieval bridge.

Reproduced from engraving after John Slezer in "Theatrum Scotiae", *1693.*

This result, however it is produced, was certainly repeated again and again in these Cairngorm streams.

Two clear cases were seen in which large pine trees, exceeding two feet in diameter, and with many jagged beheaded branches, had stranded in mid-stream and held up a stony bank on the upstream side. The larger bank had collected when the tree lay in mid-stream parallel with the stream bed. A tree in such a position presented a small front to the flow of the current and had probably come to rest when the flood was still strong and able to carry a substantial load down stream. A similar sized trunk lying transverse to the stream bed had held up little material and so had probably been deposited at a later stage when the flood waters were subsiding. Ideally the stream should carry the trees in this transverse position because when the trunk lies diagonally the speed of flow round and past the upstream end gives a turning moment which exceeds that at the downstream end where friction with the log has somewhat reduced the water speed. In practice, however, the trunks get swung round in all directions by the ends striking the sides or grounding on banks in mid-stream. In practice also, when during floods the stream channel is wide, the casual grounding of a tree trunk, of any other large object, or a boulder, can hold up more boulders. The group then offers much more resistance than an individual for it behaves more or less as one large unit.[15] Further accumulation in order to be permanent usually stream-lines such a mid-stream bank, that is, elongates it upstream and narrows it to a final point.

When a substantial mid-stream bank is raised by an altogether exceptional flood—as that of the 12th-14th of August—well above normal stream level, vegetation subsequently colonises and consolidates the material until the stage is reached when the little island is tree covered. Such islands are frequent, for instance, in the Avon, five miles north of Tomintoul. These may themselves offer sufficient resistance to subsequent floods to encourage deep channels to form against them and for the channels on either side, if meanwhile these have been widened somewhat, to be themselves divided by new banks ; and so the process of subdividing may continue.

The fundamental reason for the greater efficiency of the deeper relatively straight channels is that, for a given gradient, the forces impelling the water downstream are proportional to discharge, which involves cross-sectional area and velocity, and the forces retarding the flow are proportional to the wetted perimeter.[16] This is an over-simplification especially as friction is also related to velocity, but serves as a first approximation. The ratio of discharge to wetted perimeter is distinctly greater in the deep sections of channel than in the shallow.

A further and more widely recognised form of distributary development also occurred on the wide flat floor of Glen Luibeg about a mile upstream from Derry Lodge. Flood deposition here had been so active that irregular fan-shaped deposits were visibly raised above the general level of the neighbouring valley floor. The flood waters had, in places, burst the bounds of such fans and formed new channels

Reproduced from engraving after John Slezer in "Theatrum Scotiae", 1693.

on the lower ground on one side or the other. This is, no doubt, a major cause of distributary pattern especially in rivers which are actively aggrading as in the case of melt-water streams from glaciers which, as in the Austerdal (Sogne, Norway), open into wide U-shaped valleys, or better still in south-east Iceland where mighty melt-water streams emerge on to the coastal plain almost at sea level. The ideal circumstances occur when the flat floor is markedly wider than an individual fan and so the river is free to change its position in the course of several years or decades.

A major factor in this form of distributary development is the natural tendency of such streams to form reaches and fans as was long ago pointed out by R. D. Oldham [17] in a paper of which unfortunately only a brief abstract was published. Oldham referred to the rivers of the great Indo-Gangetic Plains with their heavy load of debris and their variable seasonal discharge. He pointed out that if, for one of a variety of reasons, water became concentrated in a somewhat deeper channel the increased efficiency led to increased velocity and to still deeper scouring of the channel and so to a local increase of gradient. Such channels or reaches would eat back upstream, whereas downstream a fan would form as a result of the local increase of load coupled with a local decrease in gradient, for only the immediate channel of the reach would be lowered and not the area downstream in which no concentration of waters had occurred. This association of reach and fan can be readily seen in streams as contrasting as the great outwash rivers of South-east Iceland, where they can be detected even on the 1 : 50,000 maps, in the lesser melt-water streams of Norway, in streamlets on the sands of any seashore, and in laboratory stream troughs. It is therefore a fundamental characteristic of the transport of solid load by water in open channels of unrestricted width. Study on the sea shore and in the laboratory is particularly helpful because one can examine the reaches and fans evolving both when deposition predominates and when the change over to erosion is occurring. On a sandy seashore, as at Scolt Head Island, little streams often flow during a falling tide from an elongated lagoon across the bar to the seaward. Erosion predominates down the steeper slope of the bar, but is replaced by deposition if the gradient slackens. In the laboratory, varying the tilt of the trough or varying the solid load introduced, can readily change conditions from those of erosion to those of deposition. Although deposition provides the ideal conditions for distributary formation, it is revealing to note that it can also occur at least in the early stages of the change over to erosion. When this happens any new distributary channel soon cuts down below the level of the neighbouring banks of deposits and we have, with a constant discharge, more or less repeated the condition which occurs in nature when a flood subsides and the stream level falls.

Oldham stated that the reaches tended to eat their way upstream followed by their associated fans. But in the laboratory where one can introduce and vary the solid load as well as varying the discharge and gradient, the reach and fan sometimes travel slowly upstream and sometimes downstream. It is tempting to suggest that they move

downstream when the load is increased relative to the discharge, and upstream when it is decreased. But anomalous movements in fact occur probably due to a particular reach and fan, at its peak of growth, dominating its neighbourhood whether the stream as a whole is depositing or eroding, for a reach temporarily more or less controls its supply of load irrespective of that in the stream as a whole. Each reach and fan has a very short life—of growth, maximum activity, and decay—compared with the stream that gives it birth.

The accidental birth of a reach has been mentioned. Accident, no doubt, it must be in the first place, but an easy and frequent accident which turbulence can greatly aid if not initiate. Turbulence is receiving very great attention in modern hydrodynamics. Leighley [18] was quick to see the advantages to the geomorphologist of applying turbulence to the problems of river erosion and deposition. Although he has changed certain of his views subsequently [19] he stressed the fundamental fact that local increase of turbulence leads to an increased upward movement of debris and to scouring of the bed, whereas a local decrease of turbulence leads to a settling of the debris and to local deposition. The pot-hole has long been recognised by geomorphologists, and when one sees it in a small glacial overflow channel of moderate gradient on the scale of the Burn of Vat, Dinnet (O.S. 1 inch, Pop. Ed. Sheet 44, G9) twenty yards across and many times wider than the little gorge through which the stream entered it, the potentialities of this admittedly severe form of turbulence strike one afresh. Eddying water masses formed at rapids entering Lake Mjosa (Gudbransdal, Norway) have been seen to maintain their individuality and motion sufficient to control the position of logs in the lake for fully twenty-five miles of its length. The eddy, in taking fast-moving threads of water deep down to the river's bed, or hard against its banks, plays a most important part in organising the bed shape and load distribution in streams bounded by loose material, as well as in those incised into the solid rock. It is far easier to start an eddy in a moving mass of water than it is to dig a hollow in even the loosest of sandy beds. So the lesser accident we require is that of the juxtaposition of two threads of different water velocity. If the first act of the resulting eddy is to scoop out a little loose material from the stream bed then the requirements for its growth have been satisfied ; the small hole encourages the further growth of the eddy and this increased turbulence scours out the hole more deeply until the eddy throws up material actively into the moving waters above. This leads to temporary over-loading immediately downstream from the eddy, which in turn leads to deposition and to the formation of a small fan ; and so the cycle proceeds.

Scour holes form so actively in laboratory streams that they are an embarrassment when the long profiles are being measured and especially when they are drawn up, as they have to be, on an exaggerated vertical scale. They then resemble most unnatural deep vertical pits. Even the lazy and diminutive upper Cam has scour holes formed at sharp bends nearly eight feet deeper than the normal bed. Scour holes forty or fifty feet deep would seem easy to maintain in large

streams and their sporadic appearance from place to place and time to time may well, in the course of some thousands of years, scour the rock bed far below the normal surface of alluvium in the river's bed. This may help to explain the usual cross section of gently sloping river valleys which show alluvium covering bedrock to a depth far greater than the depth of the normal or even of the flood stream channel.

There may well be many other ways in which streams sub-divide their channels, but the effects of the recent floods in the Cairngorms certainly seemed to exhibit several important ways in which sub-division can occur, and the well-known distributary pattern can form.

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THE ROADS OF SCOTLAND
II. STATUTE LABOUR ROADS: THE FIRST PHASE

DONALD G. MOIR

AFTER the Roman period, no roads were made in Scotland until the seventeenth century, except the occasional 'causeway' over boggy ground: in 1506 James IV gave five shillings to "ane man biggit ane brig our ane moss". Roads in the modern sense were not needed in medieval times, when all travelling was done on foot or on horseback, and merchandise was generally carried on pack-horses. The few wheeled carts and waggons which were in use for the transport of heavy goods made very slow progress, and in their place sleds (sledges) were often used, which were less liable to sink into the holes filled with water and mud which were a feature of every highway. The word 'road' itself did not come into use until the seventeenth century, the Scottish word 'gait' or the English word 'way' being used when speaking of a road generally, the description 'high gait' or 'high way' denoting a main road. These 'ways' were merely narrow winding tracks; in a dispute in 1635 about encroaching on a road, it was reported that "the horse way" was between three and four feet in breadth and "the Kirk road" two foot and a half or thereby.

The introduction of coaches created the need for proper roads. The first coach seen in Scotland was brought by Queen Mary when she came from France in 1561; the Regent Morton had one in 1577, and in 1590 Queen Anne drove from Leith to Holyroodhouse in a Danish coach drawn by eight horses. By a Privy Council Ordinance of 1611 noblemen were required to travel in Edinburgh on horseback or in coaches to avoid being accosted in the streets by importuning citizens.

The Scottish Parliament first gave attention to the highways in 1555, when it enacted that all common highways to and from free burghs should be kept clear of obstruction, an Act repeated in 1592 with penalties for disobedience. An Act of 1593 for repair of the causeway of the Canongate reveals that a toll had been charged at some earlier period for its repair, and the bailies and council of the Canongate were authorised to charge for the next three years twopence Scots on every full cart and one penny on every laden horse coming through the Water Gate with goods for sale in the market. In 1597 there is mention of an Act for the causeway of Cowie Mounth (the ancient and important 'King's causeway' between Aberdeen and Stonehaven), and of another for making a causeway on Edmonstone Edge (south-east of Edinburgh), but in neither instance have details been preserved.

When James VI went to London in 1603 he found that repair of the highways in England had, since 1555, been the responsibility of the Justices of the Peace, and he applied this scheme to Scotland. On

his direction the Privy Council in Scotland issued these instructions to the Justices in 1610 :

" You ar all of you to conveine togidder yeirlie four tymes a yeir, viz :—The first Tyisday of Februare, the first Tyisday of May, the first Tyisday of August, and the first Tyisday of November. . . .

" You are lykwyse to be cairfull concerning the upholding and repairing of the briggis that ar not utterlie ruyned, that some course may be taikin by the cuntrey next adjacent to give some supplie for that matter. . . .

" And also you ar to provyde for helping of the kingis heiche wayis alsweill for the benefite of careagis as ease of passingeris, and speciallie you ar to be cairfull that no privat persoun encroatche upoun the same way by making the same straitter [narrower] nor formerlie it hes bene. . . ."

These instructions were confirmed the next year when the Justices were authorised " to gif ordour, according as they sall think most convenient and with least greiff to the subjectis, for mending of all hie wayes and common passageis to or frome ony mercate townis within that shyre ", but subsequent history shows that these instructions were in general ignored. In 1616 an impetus was given to road construction in certain counties by an intimation from James VI that he proposed to visit Scotland in 1617, whereupon the Privy Council nominated Justices of the Peace on the King's route through Scotland " for sighting of the wayes and passageis . . . for causing of the same to be enlairgit and mendit and maid passable for cotches and horsis ", and decrees were passed for carrying out their recommendations.

The first applied to the route between Falkland and Perth and thence to Dundee, dividing it into eight sections and specifying the parishes which had to repair each section : 1—between the burn of Craigie and the causeway on the north of the Bridge of Earn ; 2—from the east end of Sheillis [Seals] Bridge on the east of the Bridge of Earn to the mid burn in the glen of Abernethy that runs to the south to Mountquharry ; 3—from the said mid burn to Falkland ; 4—from Invergowrie to Rossie ; 5—from Rossie to Craigdallie, Kinnaird and Flawcraig ; 6—from Flawcraig to Craigburn and Rait ; 7—from Rait to Shanry ; 8—from Shanry to Perth and Scone. It was enacted that : " everie plough in ilkane of the saidis parrochynnis fund ane sufficient workeman to the nomber of XI men daylie till the worke be perfytit, the one half of thame with spaides and the uther with schoolis, and that they worke tua dayes in the oulk, viz. Twisday and Thurisday, fra sex houris in the morning till sex houris at nicht, on thair awne chairges and expensis, beginning at such tyme as the commissionaris sall appoint ; and that in everie parrochyne thair be ane honnest man appointit for attending on everie ten of the workemen, and that everie gentleman landit within the said parrochinnis haveing sex pleughis of land furneis to the saidis workemen ane pick or mattok or gavillok or quarrell mell or irne wadgeis requisite to the said worke for everie sex pleughis ; and that the saidis passageis be sextene fitt of breid : as ane act maid and sett doun be the saidis Justices of Peace to this effect at lenthe beiris. . . .

" Thairfore ordanis letteris to be direct chairgeing all and sindrie the noblemen, baronis, gentlemen, and parrochynnaris abone writtin . . . that they and everie ane of thame for thair awne pairtes do and performe that poynte of dewtie in the said service whilk to thame apperteyneth and whilk to thame is injoyned, and that they on nawayes mak ony excuise, refuise, or delay upoun or under quhatsumevir cullour or pretext, as they and everie ane of thame will answer to the saidis Lordis upoun thair heighest chairge and perrell, and under the pane to be callit, persewit, and punist in thair personis and goodis at the arbitrament of his Majesties Counsall as hinderaris of his Majesties service and contempnaris and dissobeyaris of his Majesties royall prerogative and commandimentis."

Similar Acts were passed for the counties of Berwick, East Lothian and Linlithgow, and in this way originated the " statute labour roads ". These were roads repaired by a system of personal labour under various statutes passed in the seventeenth century, in contrast to the turnpike roads (to be described in a later article) made in the eighteenth and nineteenth centuries. This system of personal service lingered on in some counties until abolished in 1866. In Berwickshire the highway to be repaired in 1616 ran from Berwick by Lamberton, Ayton, and the common moor of Coldingham to Cockburnspath and Dunglass Burn, and through East Lothian it ran from Dunglass by Hedderwick Burn, Pencraig, Cottieburn, Preston and Edinburgh Brae to Edinburgh. Through Linlithgowshire the highway ran from the Howford of Almond to Winchburgh and the bridge of Linlithgow. The only other recorded report came from the Marquis of Hamilton, who reported that the way between Glasgow and Hamilton, and from Hamilton to Lesmahagow, was passable for coaches and carts, but from there to Drumlanrig there was no passage for coaches nor carts ; and he promised that the way should be mended for horses.

The orders of the Privy Council, and the warnings of penalties for neglect, seem to have been taken lightly, for on the 16th of April 1617, when the King was actually on his way to Scotland, we find the Council writing to the Justices for Berwickshire that, although they had given specific instructions for repair of the highway, " nevirtheles nothing as yitt is done thairintill, sua that his Majestie in his passage and way through the saidis boundis is lyke to be verie far impedit and hinderit without remeid be provydit ", therefore the Justices must " repair and mend the saidis wayes and mak the same passible for coitcheis and cairtis within ten dayes, under the pane [penalty] of rebellioun." What work was actually done is not recorded, but James took three days on the journey from Berwick to Edinburgh.

In the Parliament presided over by the king during his visit, an act was passed to make more specific the duties of the Justices :

" The saidis commissionaris and Justices of peace ar heirby authorized with power to gif ordour (as they sall think most convenient and with least greif to the subjectis) for mending of all hie wayis and passages to or from any mercate toun or sey poirt within that schyir : . . . the samyne suld be of Tuentye foote of measure in breid at the least. . . .

"And that the saidis Justices manteane the same with all uther wayis frome any toun in the paroche to the paroche churches in the estate that thai ar: And where they find anye necessitie of otheris wayis from any toun in the Parochin to Paroche Churches They sall informe his Majesties secreit Counsell thairoff who sall give thame thair Directioun thereanent. . . . And gif anye persoun refuis to concur for mending of hiewayis and passages the said Justices sal have power to censure and puniche thame according to thair discretioun."

That this did not produce results we can gather from the few references to highways in the next ten years. A reminder sent in 1619 by the Privy Council to one of the Justices in Annandale brought the reply that he had called a meeting to survey the highway, but only one other would go with him; however, they had appointed the constables of the parishes of Gretna and Renpatrick to see a road made from the Kirk of Gretna to the ford of Sark twenty-four feet in breadth, and mention that the Kirtle Water and the Sark Water were so changed that "they ar full off quik sand and everie yeir thair perischis baith som off the Kingis subjectis and off the guidis quhilk is drivine that way". And what was probably a description of roads generally is contained in a petition lodged in 1621 by the parishioners of Balerwyne and Portmoak narrating that: "The passage at the Guilletis at the east end and mouthe of Leavin, being a commoun and ordinair passage betuix St Johnnestoun [Perth] and Edinburgh, is now so worne and decayit that it is become unpassible for men or horsse, sua that merchantis and passingeris travelling that way ar oftymes in danger of thair lyves and pakis, and some hes perrishit, and sindrie horsse and packis hes bene cassin away, and, yf some present course be not tane in this sommer for helping, mending, and repairing of the said passage, all travelling betuix St Johnnestoun and the Ferreyis through the Guillettis will cease. . . ." The Council granted their request to take two pence from every passenger on foot and four pence from every horseman travelling along the Gullets eight days before, and eight days after, the four markets and fair days of St Johnstoun in the coming year, for repair of the road. It was said of the Soutra road in 1624, "that thair is a part of the commoun hie way and passage betuix Chingilkirk and Sowtra so worne and spoylled as hardlie is thair ony jornaying on horsse or fute that way bot with haisard and perrell;" the Council instructed the Justices to get it mended and "maid passable for men and horsse".

When Charles I succeeded to the throne and proposed coming to Scotland to be crowned he asked the Privy Council in March 1627 to see that "our hie wayes be made faire and passable for coaches and utherwayes, as they war in the tyme of our lait deir father his last being thair, and the rather in caice we sall taike occasioun shortlie to repaire thither. Thairfoir our pleasure is that yow give speciall directioun in our name . . . that the high wayes may in lyke maner be made readie for our passage. . . ." The Council thereupon appointed the landed proprietors to see to the highways within their jurisdiction, and when Charles fixed September 1628 as the date of his visit, the Council gave orders for the highways "to be perfyte" before the

24th of August. The Sheriff of Edinburgh was particularly instructed to repair the highway between Edgebuckline Brae and the Water of Almond, " whilk he, being personalie present, promeist to do ". The Council reported to the king that his various orders had been carried out, but they added that, to their great grief, they could not see how they could provide a reception which the honour required, " for your Majesteis coffers ar so emptied and your Majesteis exchecker so exhausted that there is nather moneyes in your coffers nor rents to come in " to meet the necessary expenses of his visit, and they suggested he postpone his visit until the spring of 1629. Charles agreed and so, early in 1629, the Privy Council was again busy issuing instructions about the repair of the highways along which the king would travel ; in the sheriffdom of Edinburgh the inhabitants should " come to the repairing of the said hiewayes, furnished with mattockes, gavelockes, hurlbarrowes, uther barrowes, schuills, creills, skulls and uthers necessarie instruments fitt for repairing of the saids wayes ".

It is doubtful if any work was ever done. Charles did not come in 1629, and when he said at the end of 1632 that he would definitely come for his coronation in 1633 all the orders and instructions for repair of the highways had to be given again in detail. In April, less than two months before his visit, the Council records that although " missives wer directed to the persons particularlie abonewritten for this purpose, they have beene so careless and negligent heerein as no kynde of diligence hes beene done be thame, at the least there is nane of thair diligence reported " ; and instructing them to ride the highways on the King's route and consider what repairs were needed.

The king's visit over, the roads were again neglected ; ecclesiastical affairs now took precedence, and the times were not propitious for ordered progress. There is a glimpse of conditions in 1642 on the highway from Edinburgh to Perth at the east end of Loch Leven, the subject of a previous complaint in 1621. There were " manie deepe ditches and sinkeing myres betuix the said bridge [of Portmoak] and the toun of Scotlandwel, commonlie called the calses [causeways] of Scotlandwel, quhairthrow diverse of his Majesties subjects have perished, manie have beene in hazard of their lyffes, and all are hindred in thair lawfull affaires that way ". The Council thereupon authorised a duty of fourpence for every horse or horseload, and twopence for every foot-passenger crossing the bridge to be spent on the bridge and causeways in question.

In this troubled period appeared one who might be considered the first road contractor, Sir James Hope (1614-1661), at this time working the lead mines at Leadhills. An Act of Parliament in his favour in 1649 declared what pains and charges he had incurred in repairing the highways from Edinburgh and Leith to Leadhills, Carrick, Galloway and Nithsdale, and grants his request " to caus mend and repaire any whatsomevir his Majesties hiewayis within the Kingdom leading to the head burghes and seaportes thereof or from anie Toune, village or seaport to ane uthir "—but no payment is suggested. These powers were confirmed in 1649 and again in 1661.

After the Restoration fresh instructions were given to the Justices

of the Peace, in 1661, " to give order (as they shall think most convenient and with least greiff to the Subjects) for mending of all heighwayes and passages to or from any mercat toun or Sea port within that Shire . . .", the same instructions as were given nearly fifty years earlier. Less attention than ever was paid to them, but one important road was maintained by the burgh of Aberdeen—the causeway of Cowiemounth. An Act of 1661 narrates that from 1634 it had been for a time maintained by tolls collected on the road, now it was broken and ruinous, and Parliament therefore gave new powers to collect tolls for its repair—every foot man twopence ; every horseman eightpence ; every horse load of goods eightpence ; every ten sheep eightpence ; every cow or ox fourpence. In 1663 a request was made for tolls on the causeway between Coltbridge and Corstorphine because of " divers quagmires and other impediments, whereby it is hardly passable in the winter season for horses coaches or waggons ". Clearly the powers given to Justices for repair of the highways were not effective and the highways in 1661 were in much the same condition as in 1610 : new powers were needed, but before dealing with the second phase we shall see what had been done about bridges.

Bridges

From the beginning of the reign of James VI in 1567, Parliament, the Privy Council, and the Convention of Royal Burghs, were all concerned about the decaying bridges. The records of Parliament for 1567 include the brief note among matters to be considered : " Anent the reparatioun of briggis decayit, namelie Crawmound Brig, Magdalane Brig and utheris ", but no further details. It was another fourteen years before they were again mentioned, with the addition of Leith Bridge, but again no details. The only money available at that time for repair of these bridges was a legacy of 100 merks (£66, 13s. 4d. Scots) each left by Abraham Crichton, Provost of Dunglass, for Cramond Bridge and Magdalene Bridge, which the Privy Council requested payment of in 1575 as " the saidis briggis hes greit neid of mending and reparatioun ; the ane being alreddy rewynit and the uther in dangeare of falling gif it be not spedelie helpit ". By 1587 Cramond Bridge had collapsed, as in that year Parliament considered a supplication from the surrounding counties, declaring that the main route to Edinburgh " wes be the brig of Crawmound quhilk now and hes bene this lang tyme fallin doun and na passage hed or may be hed thairby ; quhairthrow be the grite abundance of watter at the said brig commounly rynnand sen the fall thairof thair is divers personis perischit therein and na commone passage thereat nother on fute nor horse ; to the greit hurt, wraik, and discomoditie of the haill lieges of the saids sherifdomes and utheris resortand thairto ; quhairupone thai menit thame to his Majestie of befoir quhen remeid wes promeist to be providit albeit as yet oversene ". Parliament appointed a commission to view the bridge, but nothing more was done as twenty years later there is still the same complaint that since the fall of the bridge sundry persons had lost their lives in the Water of Almond.

Parliament in 1607 remitted the matter to the Privy Council, who comment " that it is a verrie grit reproch and sclander to the haill cuntrie, that the Brige of Crawmond . . . at one of the most commoune passages within the haill kingdome . . . sould have lyne so many yeir bygane unrepairit, the foord and passage at the said Brig being so difficill and dangerous ". They propose that a new bridge be built, " and seing this cannot be done bot by the benevolence, helpe, contributioune and voluntarie assistance of noblemen, prelatis, barronis, gentlemen, and utheris weill-disposed persones ", invite their contributions, and " to the effect they may be better steired up to the furtherance of this sa necessar a wark ", the Lords of Privy Council, as also the Lords of Council and Session " hes verrie frielie, willinglie and franklie begune with thair contributiounes, and help thairunto and thay no way dout bot all utheris good subjectis quho ar ony way twichit with the regaird of the commoune weill will kyth the lyk guid will and favourable dispositioune hereunto ". The appeal fell on deaf ears, for ten years later, in 1617, there was still no bridge, and a second appeal was sent out, with two men " of approved fame, honnestie, and expectatioun " appointed to receive contributions and to keep a record of all the contributions. This time they were successful ; the burgh of Edinburgh, for example, gave £200 out of the fines in 1618, and the date 1619 on the present bridge (Plate 4) shows when it was completed—fifty years after Parliament first began to discuss it. There is no record when Magdalene Bridge was repaired or rebuilt.

The third bridge to be mentioned in the records of Parliament is Perth Bridge. A spate in 1573 washed away three arches of the bridge, and after the Town Council of Perth had spent considerable sums in repairing it, Parliament in 1578 approved " ane generale taxatioun of the soume of 10000 merkis to be upliftit of the haill liegeis of this realme for supporting and beting of the said brig ". Exemption was given to Ayrshire, because they had recently contributed to the repair of the Bridge of Irvine. The Privy Council decided that the 10,000 merks should be shared as follows : £2424, 2s. 10d. by the Spiritual Estates ; £2424, 2s. 10d. by the Barons and Freeholders ; £1212, 2s. 5d by the Burghs, and £606, 1s. 4d. by the feuars, tenants and occupiers of royal property. The work was done, but in 1586 the town council reported that " the Brig, having twyse fallin doun and decayit, and laitlie being erectit of tymmer is reddy to fall without present help ". They complained in 1599 of the heavy burden by the frequent repairing of their decayed and ruinous timber bridge and said they had therefore undertaken the rebuilding substantially of stone, to be met by a voluntary contribution to be uplifted yearly from the citizens until the bridge was finished. By 1609 they had made so much progress that Parliament granted 5000 merks a year for seven years out of His Majesty's revenues. The bridge was completed in 1617 but it had a short life ; in a great flood in 1621 " ten arches or bowes of the bridge, with their pillars, were broken doun upon the 4th of October, and one onlie left standing, for a monument of God's wrathe ". Hearing of this, the King wrote to the Privy Council that he was most concerned about the loss sustained by Perth, and they appointed a Commission

to consider ways and means for a new bridge. Nothing seems to have been done, for two years later, in 1624, James wrote again, saying that " manie not onlie of the tounsmen by thair supplicationis, bot otheris both countreymen and strangeris, have related to us the ruynous and deplorable estait of Perth ; whiche hath moved us seriouslie to tak to hairt the saveing of that poore towne frome utter ruyne and wrak, and to begin with the re-edifeing of the bridge thairof . . . [therefore] we (evin in the skairstie of our treasour weill knowne to most of yow) have begun that contributioun whiche we wishe and expect that all weill myndit Scottismen who ar sensible of publict calamiteis, and any wyse hable, may contenow, every one according to his meanis ". The royal contribution of 40,000 merks was to be met out of fines and penalties collected in Scotland—an undertaking which Charles I renewed in 1625. The " weill myndit Scottismen " did not, in fact, respond to the appeal ; it was renewed by the Privy Council in 1637, when a commission was appointed to collect the money and build the bridge. This still having no effect Parliament took the matter in hand and by an Act of 1641 " recommendis this pious and important worke to all noblemen, barrones, gentlemen, sessiones of Kirkis, meitingis of exerceises, proveists and baillies . . . desyreing every ane of them to extend such portione of the ther benevolence and christiane Liberalitie for reedifieing of the said bridge . . . desyreing also all presbetries and kirkis to give order to the severall ministers within the presbetries to stir upe the people of there particulare paroches, Dilating the equitie and pietie of the worke to extend ther liberalitie thereto. . . ." The King renewed the contribution promised by his father, to be met out of taxation and arrears of feu-duties, but despite this, no bridge was built until 1722.

For the Bridge of Irvine there was a collection or taxation in 1578, but the money collected seems to have been insufficient for the purpose, as in 1589 Irvine requested permission to charge tolls at the bridge for its repair—fourpence on every load on horseback, twopence on every " man's burden ", one penny for every foot man, twopence for each ox or cow, and a penny for two sheep.

The Bridge of Leith, mentioned in 1581, and again in 1592, lasted until 1602, when the Privy Council was told that the bridge, had for many years been ruinous, and had at last, on the 25th of January, " fallin doun to the ground ". Tolls were granted to be applied in rebuilding the bridge, like those at Irvine, except that inhabitants of Leith were to pay only a penny per day, however often they might cross. The bridge was to be repaired within fifteen days in timber work, and within three years thereafter substantially in stonework.

The Bridge of Don was described in 1587 as " now fast decaying and the north end thereof alreddie fallin doun ". Parliament appointed a commission to inspect it and authorised the Privy Council to grant a reasonable stent and taxation for its repair. In 1593 Aberdeen asked for a taxation on the counties of Aberdeen and Banff, probably granted in 1597 by an Act in that year, of which no details are recorded, for " upholding the Bridge of Don ".

A commission was also appointed in 1587 to examine the Bridge

of Ayr, and the Privy Council authorised to grant a taxation or else to charge tolls for its repair, but nothing more of this is recorded. In 1590 Inverness asked the Convention of Royal Burghs to support their petition for repair of their decayed bridge, and in the next few years the Convention supported petitions for repair of the bridges of St Andrew, Earn, South Esk, Avon, and Stirling, but none of these are subsequently recorded in the Register of the Privy Council as granted or even considered.

Tolls were authorised in 1595 for the Bridge of East Linton which was " now becum sa ruynous and decayit in the pillaris and uthiris pairtis thairof that the samin, at all stormes and tempestis is lyke to fall doun ". For the two bridges of Dalkeith over the South Esk and North Esk the tolls were to be forty pence for each millstone, and eightpence for each cartful laden with wine, timber or other gear.

A supplication for Glasgow Bridge (Plate 5) was lodged in 1598 and tolls were authorised in 1600, the licence from the Privy Council reading : " considering the lamentabill estate of the Cathedrall Kirk of Glasgow, callit Sanct Mungois Kirk, and of the Brig of Glasgow, now becum rwynous and in sindrie pairtis greatlie dekayit, sum of the cheif pillaris and under proppis being schakin, brangillit, and altogidder maid lowise throw divers greit stormis, and inundatioun of watteris, quhilkis, cheiflie in the winter seasoun, hes oftymes followit, the watteris in sindrie pairtis about the said brig being alsua sandit, and the Grene ewest thairto, quhilk wes a greit decoratioun to the citie of Glasgow, now almaist altogidder distroyit and worne in sindrie pairtis throw want of calsayis, briggis, and sic uther helpis and materiallis ". The magistrates are to have power to collect these dues: for every horse laden with victual and other commodity passing along the said bridge, or from the water, from unfreemen and travellers fourpence ; for every thousand green herring inbrought and sold within the freedom, from unfreemen fourpence, and from freemen twopence ; for every packed hogshead of herring, from unfreemen twelve pence, and so on, and for every load of victual brought in the town and passing " doun the watter ", from unfreemen sixpence, all during the next nineteen years : one half of the proceeds to be employed in repairing the Cathedral Kirk, " the other half in reparing and uphalding of the said brig, removing of the said sand frome the watter, mending and bigging of calsays for the help of the said grene ".

The tolls were renewed in 1618, when the Town Council reported that the bridge, " quhilk is ane of the maist remarcable monumentis within the kingdome, being in the sex hundreth and ane yeir of God, wes verie fer decayit and at the poynte of ruyne, the pilleris, pend and undirpropis of the brig being so schaikin and brugille by the inundatioun, force and violence of the watter of Clyd as the same wes become altogidder louse, to the appeirand overthraw of the said brig ".

In quick succession licences were granted by the Privy Council between 1599 and 1607 for tolls for the bridges at Kirkintilloch, Inchbellie, Auchendinny, Gairney, Lasswade and Kirkcaldy.

In 1605 appears the first of the modern bridge contractors—John Brown of Gorgie Mill. It had been reported that the ford at Saughton-

hall on the Water of Leith had been so washed away that several people had perished in the water in the previous winter, and as the nearest bridge, the "New Brig" was very decayed, John Brown, a "werrie honnest, famous and ansuerable man", had undertaken to build a bridge of four arches, all the pillars to be of massive stone work and the arch to be of timber. Tolls were therefore granted for the work, to be collected from passengers crossing the New Brig or the fords on the Water of Leith at Saughtonhall Ford and Slate Ford, and Brown signed a bond on the 31st of May 1606 to build "a sure bridge for man and horse'', a little below Dalziel's Mill at Saughtonhall. It was 1617 before the bridge was finished; whether his account was not paid or subsequent work was necessary is not clear, but in 1625 Charles I directed that fines on shopkeepers in Linlithgow for charging excessive prices should be used for the bridge.

The next bridge to receive consideration was the old bridge over the Nith at Dumfries, a "verie large brig of mony bows", which by 1609 was in a dangerous condition, so that "at everie tyme of the rysing and swelling of the watter, quhilk sometymes will ryse to the verie heicht of thair said brig, the saidis provest and bailleis luikis for the utter overthraw of thair said brig". Tolls were therefore authorised on goods, etc., crossing the bridge; each pack of goods two shillings; each horse sixteen pence; each cow sixteen pence; each sheep twopence; each lamb one penny; each pack of skins two shillings; each daker of hides twelve pence; each barque coming to Dumfries thirteen shillings and fourpence—a big increase from earlier tolls on other bridges. The tolls were renewed in 1616, but either the tolls, or the repairs, were not enough to maintain the bridge and the Town Council's fears were realised; in a storm in the winter of 1619-20 "fyve of the best and strongest archeis and bowis of the same wer overthrowne and raised to the ground by the violence and force of the Water of Nith". Immediate steps were taken to raise money; in view of the importance of the bridge as the passage between Scotland, England and Ireland, the Privy Council "have thoght it more expedyent and les grevous to the subjectis to try thair benevolence, and what every one of thame will frielie and willinglie contribute [nor] to impose ane taxatioun upon thame". All the contributions were to be entered in a book, and if the voluntary contributions were not sufficient for the bridge, so that a compulsory taxation was required, the contributions would be deducted when assessing the taxation on the contributors. In fact, the voluntary contributions were sufficient and the bridge was rebuilt within a year.

GLOSSARY: *gavillok*—iron crowbar; *skulls*—baskets; *brangillit*—shaken; *quarrel mell*—stone mallet; *kyth*—show.

To be continued

SOURCES: Acts of the Parliaments of Scotland.
Register of the Privy Council.
Records of the Convention of Royal Burghs of Scotland.

THE DRAINAGE PATTERN AND UPLAND SURFACES OF SOUTH-CENTRAL WALES

A RE-EXAMINATION IN THE LIGHT OF EXISTING THEORIES

R. J. Rice

The pattern of Welsh rivers has for long attracted the attention of geologists and geomorphologists. In 1866 Ramsay first offered an explanation of the course of the epigenetic River Dee,[1] while six years later he extended his hypothesis to many other rivers of England and Wales[2] and expressed the view that there formerly existed a connection between the present-day drainage of Wales and that of southern England. This idea forms a recurrent theme in a number of articles on the same subject, notably those by Davis[3] and Buckman,[4,5] published at the end of the nineteenth century.

An outstanding contribution to the study of Welsh drainage came in 1900 when Lake[6] postulated an initial stream pattern which radiated from Snowdonia and which he suggested had originated on a former domed Cretaceous cover. In 1934 he attributed the break-up of this radial system to collapse of the dome and deflection of the streams into concentric courses.[7] This theory has close affinities with that advanced by Strahan[8] to explain the relationship between the rivers and geological structures of South Wales. Interest in Strahan's interpretation has recently been revived by O. T. Jones in his Anniversary Address to the Geological Society of London.[9] Finally mention must be made of Linton's[10] hypothesis which envisages the former Cretaceous cover being tilted in an easterly direction and so initiating a series of major east-west consequents.

Such theories must form the background to this account of the early geomorphological history of part of the Welsh massif—the Wye basin above Llyswen.[11] In almost all the theories concerning the origin of the Welsh rivers the Wye is considered as an important lineament in an epigenetic drainage pattern. The reason for this is clear even from a small-scale geological map (Fig. 1). Between its source on Plynlimon and the right-angled bend at the foot of the Black Mountains escarpment the Wye traverses without deflection the axes of two powerful and complex folds. A few miles west of Llangurig it crosses what O.T. Jones[12] has termed the " Central Wales Syncline ", while downstream from Rhayader it passes over the crest of the " Towy Anticline ". Its superimposition appears, therefore, indisputable. A similar analysis reveals that a considerable proportion of the other streams in the upper Wye basin have also been superimposed (Fig. 2). Four large tributaries, the Marteg, Elan, Irfon and Ithon, merit closer examination. While parts of the Irfon and Ithon basins have been the subject of detailed geological studies, the first two rivers flow through areas where the structure is very inadequately known and as a consequence their postulated histories are based almost entirely on morphological evidence.

The Marteg flows first south-westwards to Pant-y-dwr, then southwards for one and a half miles, and finally reverts to its south-westerly direction before joining the Wye. Today the north-south section is of very restricted length, but the once greater importance of this trend is indicated by the stream pattern around Tylwch. Formerly there was a major north-south river flowing from near Tylwch to the Wye three miles above Rhayader and receiving what is now the upper Marteg as a left-bank subsequent tributary. A conspicuous wind-gap south of Pant-y-dwr at 1,100 feet O.D. testifies to the earliest interruption of this river, while the later reversal of the Tylwch–Pant-y-dwr segment of the stream may be attributed in part to piracy by the Severn tributaries and in part to the action of glacial meltwater.

The Elan has also been so disrupted that little of its initial southeasterly trend has survived. Again the earliest diversion was that of the lower reaches, the capture being evidenced by a broad col at 1,550 feet O.D. together with a small misfit which joins the Wye at Rhayader. More recently the original Elan headwaters have been tapped by the Ystwyth which had the advantage of a relatively short course to the sea at Cardigan Bay and probably also a zone of weakness along which to work.[13] On the other hand the area of the present Elan catchment basin owes much to the very early growth along the faulted Gwesyn syncline of a subsequent which intercepted the superimposed Claerwen-Chwefru line.

In 1942 T. N. George[14] interpreted the Irfon as composite in origin. He regarded the section above Llanwrtyd Wells as a remnant of a superimposed river which once continued southwards across the Mynydd Eppynt to join the Usk and that below Llanwrtyd Wells as a piratical, subsequent tributary of the Wye which has extended itself headwards along the Towy Anticline. The pattern of streams in the Irfon basin indicates the likelihood that this capture is merely the latest of a whole series effected by the lower Irfon. This is substantiated by the obvious disregard of structure both by the left bank feeders of the lower Irfon and by the rivers which drain the ' dip-slope ' of the Mynydd Eppynt (Fig. 1).

The course of the Ithon, the longest tributary of the upper Wye, may be divided into two parts, an upper above Penybont with a relatively straight north-south orientation, and a lower, very tortuous one. Although for ten miles from its source the Ithon flows roughly parallel to the north-south strike of the Silurian rocks, it transgresses important lithological boundaries in such a way as to suggest that the parallelism may be fortuitous. Confirmation is found near Penybont where the river traverses a strongly faulted upfold on the southern limb of the Towy Anticline. Such discordance points to a further line of superimposed drainage, an interpretation which is also favoured by O. T. Jones[9] ; he notes, in addition, the remarkable alignment of the upper Ithon with the middle reach of the Edw and considers that these sections of the drainage pattern are dismembered relics of a large epigenetic river. This view is accepted by the present writer, although it conflicts with that expressed in 1930 by Dwerryhouse and Miller.[15] The latter authors maintain that in pre-glacial times the Edw flowed

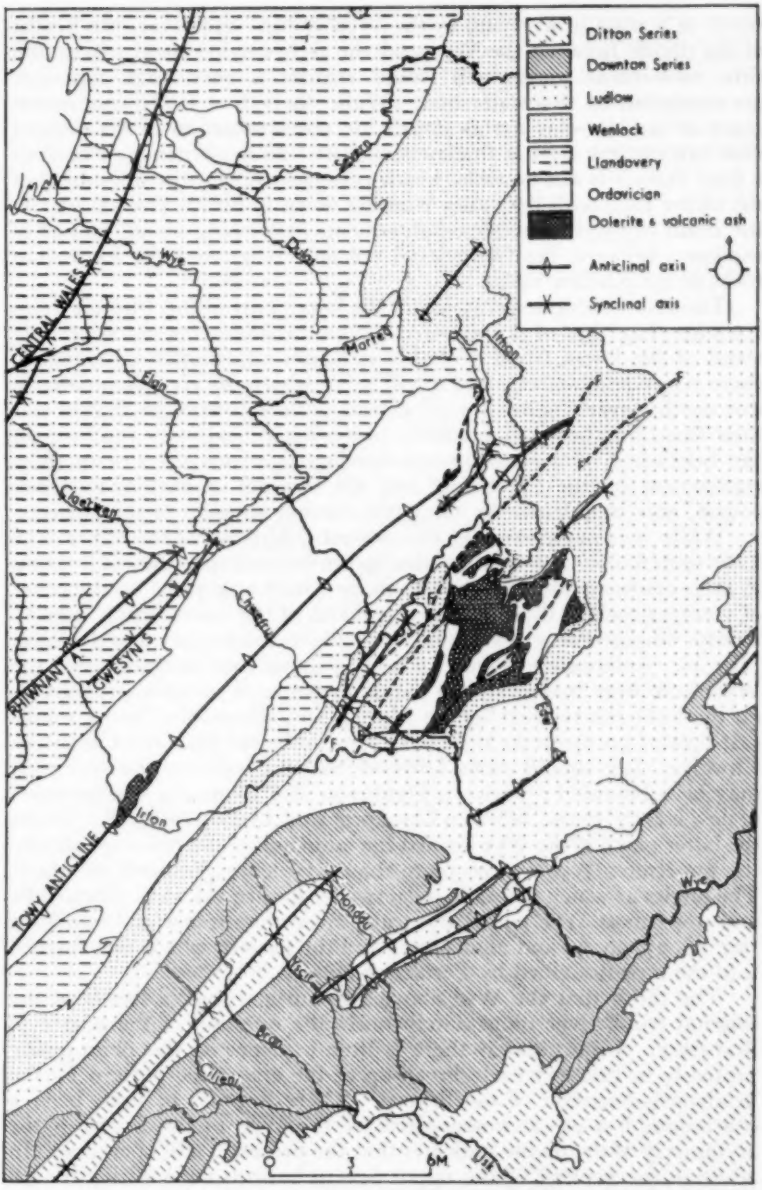

Fig. 1. The geology of South-Central Wales.

south-westwards to a confluence with the Wye near Builth Wells, and was forced to adopt its present course through the Rhulen Hills as a

result of a mass of ice lying in the Wye valley. However, the height of the divide between the Wye and the right-angled bend where the Edw now turns southwards would require a very large morainic accumulation at the watershed. While there is a fairly continuous cover of boulder-clay across the divide re-examination of the ground does not suggest a great thickness of drift. In the absence of borings a final verdict is not possible, but it is suggested that the alignment of the upper Edw with the valley running down to Builth Wells is merely the result of two independent subsequents developing along the line of weakness between the Ordovician volcanic inlier and the Ludlovian rocks of the Rhulen Hills.

The relationship to structure of the lower part of the Ithon is more complex than that of the upper. Whilst the dominant south-westerly trend of the lower Ithon probably indicates adjustment to structure, there is one reach of two and a half miles where the river flows almost due north directly across the geological grain. It appears that in this area there has been an involved succession of captures resulting in the beheading of a former south-flowing superimposed stream, now represented by the Clywedog, and the reversal of part of its lower course, now represented by the north-flowing segment of the Ithon.

While it is apparent that the present tributaries of the upper Wye have undergone considerable adjustment to structure, they still retain in their courses evidence of the drainage which originated on the cover of younger rocks. By using those portions of the rivers which seem to be superimposed an attempt may be made to reconstruct that drainage (Fig. 2). Reference to Figures 2 and 4a shows that confluent with the Wye there were two groups of parallel streams, a south-flowing group on the left bank typified by the Marteg and Ithon-Edw, and a south-east-flowing group on the right bank typified by the Elan and Claerwen-Chwefru. It is equally clear, however, that the course of the Wye itself may be subdivided ; between Plynlimon and Llangurig the direction of flow is S 55° E and between Llangurig and Llyswen S 27° E. Whilst the latter reach of the Wye formed the main axis of the drainage system, the uppermost Wye was no more than a typical right-bank tributary. The angles at which the Elan, Claerwen-Chwefru, Marteg, Ithon-Edw and uppermost Wye joined the trunk river were remarkably uniform (*viz.* 26, 27, 30, 34 and 28 degrees) and the pattern which they formed is of the type described by Zernitz as pinnate.[16]

The thesis that the Wye above Llangurig is only a feeder of the original trunk river immediately raises the question of the source of that river. Unfortunately there is little evidence on this point owing probably to the very early break-up of the epigenetic pattern by the headward extension of the Severn. There appears to have been a continuous loss of catchment area by the Wye to the Severn ; the asymmetry of the divide indicates that the process is still operative. In addition the geology of the upper Severn basin is not sufficiently well known to allow the recognition of the superimposed elements with certainty. O. T. Jones[9] has suggested that the Clywedog and the Severn headwater once maintained their south-easterly direction as far as Tylwch where they joined the Marteg and so flowed to the Wye near

Fig. 2. Some features of the drainage pattern of South-Central Wales.

Rhayader. Linton[17] has intimated his acceptance of this view, although it involves an anomalous arcuate course which calls for specific explana-

tion. If the Wye from Llangurig to Llyswen represents a beheaded trunk stream, one might seek its source by projecting the remnant alignment northwards along the bearing N 27° W. Interesting results follow, since two of the Severn headstreams, the Clywedog and Lwyd both begin by flowing south-south-eastwards towards Llangurig before being diverted along fault zones. Moreover the upper reaches of the Severn tributaries would form the western half of a pinnate system having obvious affinities with that already reconstructed. This theory, however, must remain speculative until more detailed work, both geological and geomorphological, has been completed.

The concept of a pinnate pattern centred upon the Wye is inconsistent with neither the radial theory of Lake[8] nor the hypothesis of east-west consequents advanced by Linton.[10] O. T. Jones[9] was, however, somewhat reluctant to accept the obvious alignment of the Ithon and Edw as it did not fit exactly into a simple radial plan. This is true, but if Lake's theory is modified so as to include a series of pinnate systems based upon radiating trunk rivers, the difficulty disappears. Along the eastern margin of the upper Wye basin there seems to be an abrupt change in the direction of the superimposed rivers ; on one side the dominant trend is north-south and on the other west-north-west to east-south-east. Further investigation may well show this to be the boundary between two areas with independent pinnate systems. At two points there has been competition between the systems with the Aran and Howey increasing their catchment areas at the expense of the rivers to the east.

The Morphology of the Upland Surfaces

Dominating the relief of the region between Plynlimon and Rhayader is an extensive plateau which varies in height between 1,300 and 1,900 feet and truncates indiscriminately a great variety of strata. Above 1,300 feet the terrain is generally undulating but below that height are the steep-sided, deeply entrenched valleys characteristic of Central Wales. Detailed mapping of breaks of slope allows the upland surfaces to be resolved into three distinct levels (Fig. 3). These are best developed in the Wye valley near Llangurig where the breaks of slope between the ' treads ' and ' risers ' are particularly well-preserved. The lowest level rises gently from the 1,300-foot shoulder of the valley to *c.* 1,400 feet where it is backed by an abrupt steepening of the gradient. A further flattening at 1,500-1,600 feet is separated from a summit-level surface at c. 1,700 by a second bluff at c. 1,600. To these three levels, in ascending order, the following names may be applied—the Rhudd Surface, the Gwy Surface and the High Plateau. This nomenclature has the advantage of retaining for the summit surface, which has been widely recognised in Wales outside the upper Wye basin, the general term of High Plateau.

The flats belonging to the Gwy and Rhudd Surfaces decline in height from Plynlimon to Rhayader; they are most probably of fluvial origin and related to standstills which punctuated the downcutting of the Wye and its tributaries. Corresponding features can be found in

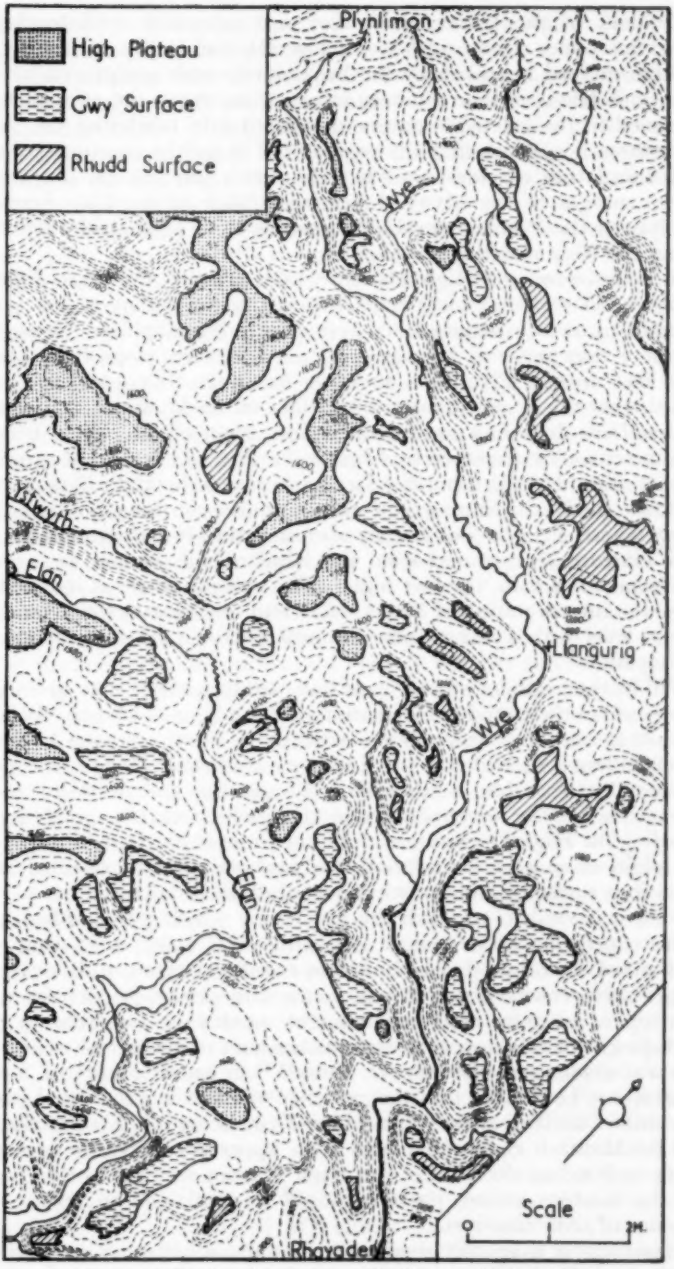

Fig. 3. Upland surfaces between Plynlimon and Rhayader.

the valleys of the tributaries; they are especially well-developed along the upper Ithon valley. Below Rhayader the continuity of the high ground is broken by the broad strike vale sculptured by the Ithon and Irfon, so that the only information about the two stages is contained in the faceted summits of isolated hills bordering the Wye. From these it appears that the regular fall in height continues downstream and that a widespread bevelling at 1,300 feet on the south-eastern margin of the Mynydd Eppynt is part of the Gwy Surface. At Llyswen the Wye was probably flowing at c. 1,250 and 1,050 feet during the Gwy and Rhudd stages.

It is, however, the High Plateau which presents the most difficult problems. Its greater local relief means that its extent is less easily defined and, as a consequence, its overall form less manifest. Nevertheless there does seem to be a general south-easterly slope from about 1,900 feet around Plynlimon to 1,700 feet near Rhayader, and it is possible that the 1,500-foot summit surface of the Mynydd Eppynt and Rhulen Hills denotes a southward continuation of this fall in height. An alternative view is taken by Miss Goskar,[18] who regards the summits as relics of a surface intermediate in age between the High Plateau and the Gwy Surface. Support for this is found south-west of Radnor Forest where a 1,700-foot fringe, almost certainly a fragment of the High Plateau, is separated from the Rhulen Hill plateau by a very prominent bluff over 100 feet high. The present writer is inclined to follow the interpretation of Miss Goskar and to correlate the 1,500-foot Eppynt level with a rather indeterminate area at 1,600 feet north-west of Rhayader.

Whilst the gradient of a series of flats within a valley may provide a clear guide to their mode of formation, the gradient of plateau surfaces confined to interfluves is much less indicative. For this reason a second line of evidence, such as that provided by a study of drainage evolution, is especially desirable. Adequately illustrating the need for more information are the many conflicting views which have been advanced regarding the High Plateau; at different times it has been interpreted as a plain of marine denudation,[19] a peneplain,[20] an exhumed sub-Cretaceous surface[21] and an exhumed sub-Triassic surface.[22]

First it is vital to establish the process by which the modifications in the superimposed drainage were effected; Lake[7] held that the break-up of the original river lines was the direct result of dislocations in the Cretaceous cover. Yet it seems unnecessary to invoke such catastrophic changes since a sufficient agency is available in the development of subsequent streams along lines of geological weakness. This was demonstrated by R. O. Jones[23,24] in another area of South Wales where he showed that the existence of a series of low-level wind-gaps vitiates the idea of the course of the Tawe being inherited unaltered from the Mesozoic cover. Likewise in the upper Wye basin the presence of cols well below the level of the High Plateau strengthens the belief that the modern stream pattern should be explained in terms of a sequence of river captures.

However, it is equally significant that not all the captures which transformed the simple pinnate system are marked by cols. It has long

been recognised that instances of piracy readily legible in drainage alignments but unaccompanied by wind-gaps are a valuable criterion for distinguishing areas in their second erosion cycle, and therefore for distinguishing peneplains from other forms of erosion surface. The application of this principle in the upper Wye basin firstly confirms that the Gwy and Rhudd Surfaces are of subaerial origin and secondly reinforces the opinion of W. M. Davis that the highest erosion facets constitute part of an uplifted peneplain.

The details may best be summarised by outlining the stages at which the various changes in the stream pattern took place. It will be seen (Fig. 4) that at the level of the High Plateau at least one major alteration—the interception of the Claerwen-Chwefru river—had already occurred. By about the same time a subsequent working westwards along the Towy disturbance had succeeded in diverting the Cammarch and Dulas, while yet another subsequent had diverted the lowest section of the Ithon-Edw. In none of the above instances is there a vestige of a wind-gap and while this prevents precise dating (no more than the latest possible date for piracy can be given) it does conclusively demonstrate the subaerial nature of both the High Plateau and the Mynydd Eppynt summit surface. There ensued before the Gwy standstill two further important modifications, the one involving the Elan and the other the Clywedog. Finally the rejuvenation which preceded the Rhudd stillstand probably saw the second interruption of the Ithon-Edw drainage line.

It must be emphasised that adjustment to structure did not end with the formation of the Rhudd Surface but has continued at much lower levels. Examples include the capture of the upper Irfon at Llanwrtyd, the loss of the Elan headwaters to the Ystwyth, and the disruption of the Marteg. Moreover reference has been confined to those captures which affected the largest tributaries and there are many cases of piracy amongst the smaller streams which have not been mentioned. One of the most significant features in the history of the river pattern has been its continuous evolution, and it is this which renders most improbable the ideas that there was a sudden dislocation of the drainage before superimposition, or that the upland surfaces are other than peneplains.

So far the upper Wye basin has been treated as a unit but the field covered by the paper inevitably raises again the problem of the nature of the right-angled bend in the Wye at Llyswen. The origin of this feature has often been discussed and many different conclusions drawn. Sir Halford Mackinder[25] has indicated on a map that the Wye originally joined the Usk by way of the low ground around Llangorse Lake; Clarke[26] has suggested that the Wye formerly joined the Usk via the high level Rhiangoll col in the Black Mountains but was diverted eastwards at a very early stage. Dewhurst[27] has advanced a third alternative, that the Usk once flowed along the line of the Llynfi valley to join the Wye near Llyswen. Lending strong support to the theories of Mackinder and Clarke are, firstly, the identity of direction shared by the upper Wye and lower Usk, and secondly, the right-angled bend itself which might well be the result

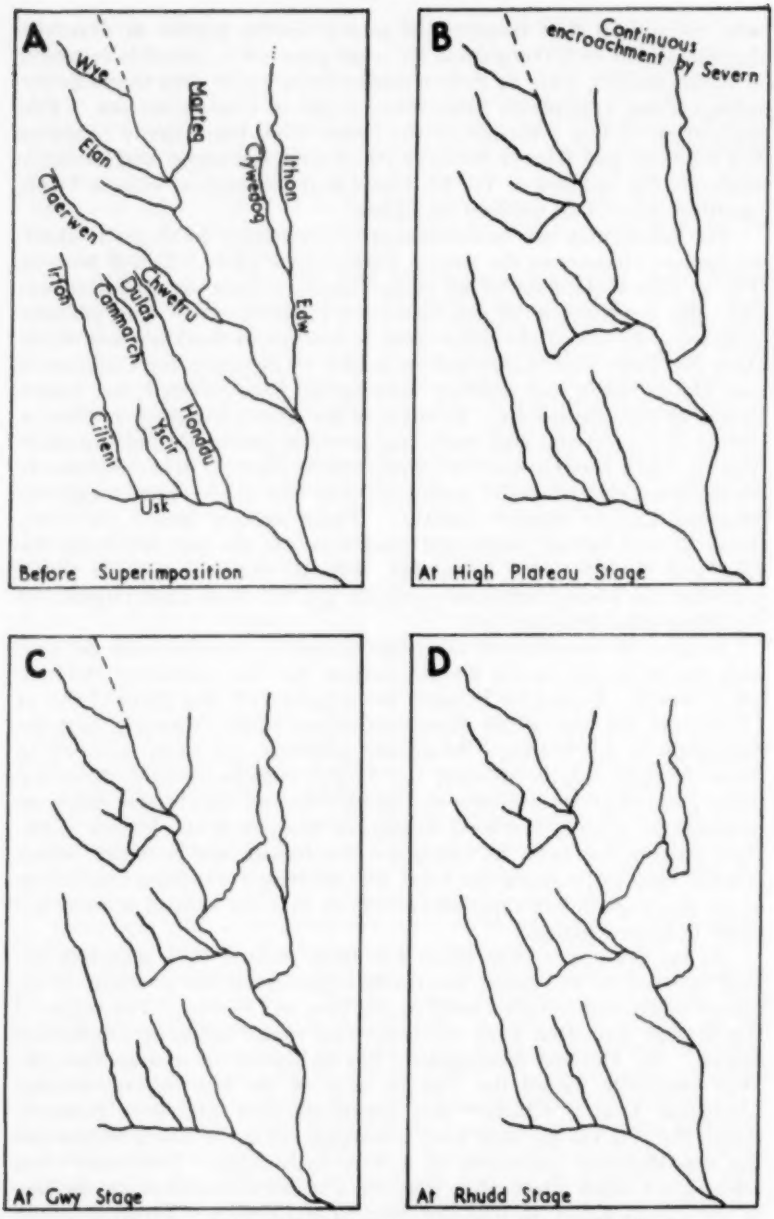

Fig. 4. Evolution of the drainage pattern in South-Central Wales.

of capture by a subsequent cutting back along the outcrop of the Old Red Sandstone marls. There is, however, a third line of evidence

which may provide in addition a means of assessing the date at which the diversion of the Wye occurred. This is the fact that a subsequent tributary of the Wye was able to intercept the superimposed Irfon at a level of 1,085 feet near Llanwrtyd Wells. T. N. George[14] maintains that immediately prior to capture the Irfon was graded to an 830-foot shoreline which lay in the vicinity of Abergavenny (a view that invalidates the significance of the upper Wye–lower Usk alignment). However a sea 830 feet above its present level would not have submerged the Forest of Dean so that the coast at the mouth of the Wye cannot have lain far north of Chepstow. As a consequence the distance from the point of capture to the sea along the Usk was forty-five miles, but along the Wye 135 miles. It seems most unlikely that the capture indicated by the Llywn-coll gap in the Mynydd Eppynt could have taken place in such circumstances.

If the view of George that the upper Irfon was graded to an 830-foot shoreline near Abergavenny can be definitely established, the capture by the lower Irfon only becomes feasible if the Wye and Usk were confluent at a comparatively late date near Llangorse Lake. By means of extrapolated river profiles George has shown that at the time of the 830-foot sea-level the Usk at Brecon was flowing at a height of 875 feet. Geomorphological mapping has shown that there was an important dual standstill when the Wye below Builth was flowing at a height of about 900 feet. Whilst correlation is not perfect, the records of the two rivers are certainly not irreconcilable.

This leaves unanswered the date at which the Wye was diverted by the subsequent at the foot of the Black Mountains escarpment. Since today the Wye at Llyswen flows at 300 feet and the Usk near Llangorse Lake at 450 feet, it seems that capture may have followed retreat of the coastline from Abergavenny to its present position near Newport. George,[14] however, claims that not only the 830-foot but also the succeeding 580-foot shoreline lay close to Abergavenny. This would delay the diversion of the Wye so late that it conflicts with the evidence of the area around Llangorse Lake. The geomorphology of the Vale of Gwent is critical and deserves careful investigation.

An analysis of the drainage pattern and upland surfaces in the upper Wye basin therefore supports the following conclusions. The upper Wye between Llangurig and Llyswen represents a major drainage line in a superimposed stream system which probably originated on a former Cretaceous cover. Tributary to the trunk river at an angle of about 30° were five large streams, the whole forming what may be termed a pinnate pattern. Among the earliest instances of stream capture was the loss of the Wye headwaters north of Llangurig to the Severn. The headward growth of subsequents has been a continuous process and the resulting piracy is attested by a number of undoubted wind-gaps. Disruptions of the Cretaceous cover were not necessarily responsible for the diversion of the original consequents.

Within the upper Wye basin three upland surfaces may be distinguished, the High Plateau, the Gwy Surface and the Rhudd Surface. Modifications of the pinnate pattern occurred above the level of the highest of these, indicating that they are all a product of the drainage,

i.e., they are peneplains. It is possible that a major change in the stream pattern of South Wales occurred at a comparatively late stage when the Wye was diverted from its original confluence with the Usk near Llangorse Lake to its present course along the foot of the Black Mountains escarpment.

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ROBERT NEAL RUDMOSE BROWN

A NOTABLE figure has gone from the ranks of geographers and explorers by the death, on the 27th of January 1957, of Robert Neal Rudmose Brown, well known to several generations on both sides of the border, for until illness cramped his activities he was a notable and welcome figure in many circles and associations. He was born on the 13th of September 1879, and received his earlier education at Dulwich College, later continuing it in the University of Aberdeen and the Université de Montpellier.

Rudmose Brown early fell under the influence of the thought and teaching of Patrick Geddes, the pioneer of town planning and one of the founders of regional geography, and when, in 1908, the University of Sheffield set up a Department of Geography, it appointed as its first head Rudmose Brown. In the development of the new subject and the new department, he found his main life's work and he threw himself into it with that amazing zest of which he was fortunately capable. He made himself one of the leaders in that particular field and the science owes him a debt of gratitude for his labours which were so worthily crowned with success. Thanks to him and to a small band of his compeers, geography was admitted in the British Isles to full status as an academic discipline. Geography with him was given a sound physical basis upon which all other branches were systemically built. His work with his students was successful and far reaching, for he was a personality as well as a scientist and a teacher. In 1931, when the Chair of Geography was created at Sheffield, he became the first Professor of Geography there and held the office until his retirement in 1945. He made university geography history too, by serving two universities simultaneously when he was Reader in Geography in Manchester from 1920 to 1922, while continuing to hold his Sheffield post. He found time to publish numerous stimulating papers and articles on geographical subjects and a book on *Principles of Economic Geography*, which ran into four subsequent editions, and was joint author of another on *The Scope of School Geography*. He served as Editor of Harrap's Geographical Series.

All his life, Rudmose Brown's main interest lay, however, in Polar exploration and Polar geography, probably largely as a result of the infectious enthusiasm of Dr W. S. Bruce, and in 1909 began his lengthy labours in the Arctic Archipelago of Spitsbergen. His major expeditions there, in company with W. S. Bruce, were in 1909, 1914 and 1919, but he visited the islands on other occasions, working on botanical problems, general polar geography and the movements of ice and glaciers. Another Fellow of the Royal Scottish Geographical Society also played a notable part on the map-making side—the late John Mathieson. The 1914 expedition had to be curtailed on the party learning of the outbreak of war, and Rudmose Brown returned home to serve on the Intelligence Division, Naval Staff, H. M. Admiralty, from 1915 to 1919. He was Deputy Leader of the largest expedition ever to set sail for Spitsbergen from Britain, that of the summer of 1919, when the writer of the present note served under him. In the field he was an arresting figure with his commanding stature and ruddy colouring, reminiscent of the historical Viking. He was a confidence-inspiring leader, a good mixer among his men, where his jovial laugh was infectious, and he was ever in the forefront when a job of work had to be done. His industry and his enthusiasm outlasted the thrills of Arctic voyagings and are to be seen in the monographs, papers and reports which came from his pen subsequently, and in the innumerable lectures he never failed to give in aid of scientific societies up and down the country. He continued his intelligence work for the Admiralty during the Second World War, and for his services King Haakon of Norway awarded him the insignia of a Commander of the Order of St Olav.

Numerous well-earned distinctions came his way—the medal of the Royal Scottish Geographical Society in 1904 for his work in the Antarctic, the Vice-Presidency of the International Polar Congress in 1906, the Cuthbert Peck Grant of the Royal Geographical Society in 1919 for his work in Spitsbergen, the Presidency of Section E of the British Association for the Advancement of Science in 1927, the Presidency of the Antarctic Club in 1932, the Presidency of the Institute of British

Geographers 1937-1938, the Presidency of the Arctic Club in 1949. As a practical geographer, he set an example which it will be well if others can follow.

DOUGLAS ALLAN, C.B.E.

EMERITUS PROFESSOR RUDMOSE BROWN was the last survivor of a great group of Scottish scientists that contributed much to the formative phases of British geography. He is of the succession that included the explorer-naturalists Wyville Thomson, Murray, D'Arcy Thomson and Bruce, and the scientist-geographers Geddes and Herbertson, and the last three had considerable personal influence upon him.

Educated as a botanist at Aberdeen, and with Flahault at Montpellier, he was appointed Assistant Professor in this subject in University College, Dundee, in 1900. The professor was none other than Patrick Geddes, though he functioned only during the summer terms, and here Rudmose Brown became imbued with the ideas that formed the core of his geographical philosophy. In 1902 he left to become botanist and marine zoologist in the Scottish National Antarctic Expedition led by W. S. Bruce in the *Scotia*. This expedition was essentially oceanographic in character, although it discovered Coats Land and the coast where two British Antarctic expeditions are currently based. On the way back after two seasons in the Weddell Sea and a winter in the South Orkneys, the expedition landed at Gough Island and Rudmose Brown gave the first scientific account of its vegetation. At sea he was concerned with the plankton work and on his return he remained with Bruce at his Scottish Oceanographical Institute housed in a building behind Surgeon's Hall in Edinburgh. This led to a commission by the Indian Government to investigate the Mergui pearl fisheries in 1907.

Rudmose Brown's appointment to a newly created lectureship in geography at Sheffield University in 1908 did not sever his connection with Bruce. In 1909 he accompanied Bruce to Spitsbergen in the Granton trawler *Conqueror* : in 1912 he was again with Bruce, but not on the 1914 expedition, for in that year Rudmose Brown visited Australia with the British Association. After service with the Naval Intelligence Department in the war years he was back in Spitsbergen on Bruce's two last voyages in the *Petunia* in 1919 and the *Easonian* in 1920. Out of this long association came his comprehensive account of Spitsbergen in 1920 and his biography of Bruce—*A Naturalist at the Poles*—in 1923. His survey of *The Polar Regions*, 1927, was one of the first volumes of Methuen's geographical series. Rudmose Brown's interest in the polar lands continued to the end of his days. He was President of the Antarctic Club in 1931 and the Arctic Club in 1949 and made a Knight of the Norwegian Order of St Olaf in 1945.

Not less important however were his achievements in Sheffield. Basing himself firmly on the belief that geography must be " treated by scientific methods " and carefully avoiding all specious or over-reaching claims for his subject, Rudmose Brown won the support of his colleagues in the Faculty of Pure Science for an Honours School in Geography. Courses were begun in 1924, five years earlier than in Edinburgh and six years before Oxford. The elevation of Rudmose Brown's lectureship to a Chair followed in 1931, a fitting recognition alike of his labours for the subject and of his scientific standing and integrity. Rudmose Brown also served his subject in other ways. In 1920 his *Principles of Economic Geography* first appeared and the fact that its third edition was reprinted as late as 1946 testifies to its readability and utility. He was twice a member of Council of the Royal Geographical Society and after acting for six years as Recorder to Section E of the British Association he occupied the Presidential Chair at the Leeds meeting in 1927. Perhaps the most signal and characteristic of all his services to geography was his acceptance of the invitation to become the second President of the Institute of British Geographers in 1937-38. His forward-looking mind saw the growing importance of the young Institute and his timely support was a real factor in enabling it to achieve the standing it now enjoys.

DAVID L. LINTON

EUROPE AND ITS BORDERLANDS : A REVIEW

HENRI BAULIG

EUROPEAN geographers have seldom if ever treated their own continent as a whole, as they have done repeatedly for Africa and North and South America. Perhaps deterred by the complexity of the subject, they have been satisfied, at most, with describing such large areas as Atlantic, Central, Nordic, Oriental or Mediterranean Europe. A Scottish geographer—the late Alan G. Ogilvie—has dared the venture and, let us say it at once, succeeded.[1] His purpose, he says, is to consider Europe " as the theatre of Western civilisation ". Thus defined, the subject covers the continent with the Ural and the Caspian depression as its conventional limits, and its " borderlands ",—the northern islands from Iceland to Novia Zemlia, the Mediterranean fringe of Africa and the " bridgelands of Asia ", from Turkey to Mesopotamia, from Egypt to the confines of Iran.

The geographer, asking himself (see the ' Introduction ') the three questions : " where is it ? what is it ? why is it there ? " is constantly guided by two distinct and yet complementary lines of research. First—there is the analytical process of considering separately phenomena of the same general order with their variations throughout the world in order, if possible, to discover their universal laws. These may be relatively simple : meteorology, for instance, is theoretically at least reducible to physics and fluid mechanics. When life and, above all, man is involved, the connections become much more intricate : it is nevertheless possible to detect certain similarities and constancies, or at least to underline the variants. This is the aim of general or world geography. Regional geography, on the other hand, aims at synthesis. It does not envisage phenomena independently but in their interplay within an appropriate spatial framework. To this end it must draw not only on general geography, but also on the most diverse disciplines such as palaeoclimatology or social history, at the risk of degenerating into encyclopaedism unless some rules, which Ogilvie sets forth clearly in the ' Introduction ', are observed : from the innumerable facts which observation offers, select only those that are relevant, not so much in themselves as in their correlations, those especially which, appearing in the patterns of landscapes, denote particular modes of life. The fundamental concept of regional geography is then that of the environment, as utilised and modified successively by human groups according to their techniques and mentalities. The regional geographer is therefore confronted with serious difficulties. He has to master his matter in its entirety so as to see the whole as composed of parts and the parts as integrated in the whole, avoiding the vagueness of generalities as well as the dryness of details. Moreover, since relevant relationships are reciprocal, the presentation cannot proceed along a simple, continuous line ; repetitions and references back and forth are inevitable. This requires a certain degree of literary skill.

For such a delicate task, Ogilvie was well prepared [2] through an initial training in history, geographical studies in Edinburgh, Berlin and Paris, personal knowledge of different parts of Europe, especially the Mediterranean lands and his participation in the studies preparatory to the delimitation of new frontiers after the First World War. From 1920 to 1923 he was engaged in a new and very interesting kind of work with the American Geographical Society of New York : to start the compilation of the millionth map of Hispanic America and, as a specimen, to write a comment on the La Paz sheet : this amounted to composing a coherent picture from sparse, fragmentary and heterogeneous material. The *Geography of the Central Andes* is an excellent example of what regional geography can do.

Europe and its Borderlands is another : a masterly piece of work, firmly grounded, patiently elaborated and brought to its point of maturity. Unfortunately, his sudden death prevented the author from putting the final touch to it. So his colleague Dr C. J. Robertson acted as " literary executor ". This he has done with commendable discretion. Apart from a few short chapters (18 pages in all) from the pen of the editor, the master's hand is perceptible everywhere, in the rational arrangement of the content as well as in the clear and simple style. The book is eminently readable, and it may be recommended not only to students and the general public, but also to professional geographers who will find in it, as well as many familiar topics, some

novel points of view. One must all the more regret the absence of bibliographical references, few, we are told, having been found amongst the author's papers. Metric equivalents of English measures and Fahrenheit degrees are ordinarily but not systematically given.

In the first part, and by far the longest (250 pages), Europe is treated as a whole, and the chapters follow in the analytical order : Land and Sea, the Ocean and the Seas, Climate, Soils, Rivers, Vegetation, Fauna, but with the constant aim of stressing the interdependence of these factors. Economic minerals are linked with geological structure and fisheries with marine hydrography. In the chapter on Climate, Fig. 8 combines the duration of the critical temperatures 0° and 20°C. with the limits of certain trees (see also Figs. 7 and 10) ; Fig. 14 accumulated temperatures with the length of the growing season. The ratio of precipitation to temperature is expressed by de Martonne's index of aridity. The distribution of dominant cereals (Fig. 15), reflects the cumulative influence of climate, soils and food-habits. The general aspects of the plant cover, the formations such as forest, grassland, scrub, tundra (subarctic and alpine) depend directly on the climate, while the various associations of plants are controlled by the general distribution of species and the local conditions of soil, water, exposure. But the natural vegetation has been largely altered, destroyed and replaced by human action, at least since the arrival of the Neolithic cultivators with their herds of domestic animals. Everywhere the clearing of forests and the enormous extension of fields and artificial grasslands have greatly fostered the invasion of the eastern steppe fauna, especially rodents. The well-known relationship of malaria with temperatures above 15·5°C. is represented in Fig. 18. The locust plagues (Figs. 19, 20) are analysed for each variety of insect into their components : breeding places, solitary and gregarious phases, areas of occurrence (Figs. 19, 20).

Human geography is introduced by a chapter on ' Man and his Culture ' as expressed in language, religion and other cultural influences. The Arabian and Turkish rule, the Crusades, the Hanseatic League, etc. have left, more or less visible to-day, their ' imprint ' on the landscape. The network of Roman roads has long guided medieval and modern trade. Urban life " is as old as western civilisation " : it spread from 3,000 B.C. (Sumer) to 150 A.D. (part of the Roman empire) and later, with a remarkable tendency to permanency of sites. " Urban architecture reflects cultural influences directly, while the effects of geography [climate, available materials] upon the style are largely indirect ". Frontiers, a classical theme in Chapter 12, are envisaged as political limits and strategic barriers, some very stable, many subject to repeated shiftings. After the First World War there was a " deliberate attempt to establish accord between territorial and linguistic limits " ; after the second war, the process was much more brutal.

The two chapters on ' Agriculture and Rural Settlement ', are amongst the best in the book. In the southern lands, three systems, largely independent, coexist : tree crops and intensive agriculture, grain crops and extensive agriculture and pastoral life. The typical form of settlement, mainly for reasons of security and protection of the crops, is the compact village ; but scattered farms appear at times in districts of intensive irrigation. Agriculture in the main alluvial lands of the South, Lower Mesopotamia, Egypt, North Italian plain, are very well described—natural conditions, traditional utilisation, progressive control of waters, introduction of new crops. In the northern lands, the arts of agriculture and stock-rearing can be seen at the most varied stages of their development, from the primitive shifting cultivation to their most progressive phases. The latter, as a rule, are not fully explained by conditions of climate and soil : in the absence of some external stimulus such as location and demand of towns, " local self-sufficiency has prevailed and traditional methods lasted long ". Moreover, " advances have often been made in method without corresponding change in rural landscape and human abodes ". The most striking contrast is that of enclosed and open fields with dispersed and concentrated dwellings.

The " bocage " of the Atlantic fringe is obviously related to the mild climate which favours stock-rearing in the open. But the hedge may just as well, as it probably did originally, protect the cultivated fields from the inroads of the cattle and prevent cattle from roaming at large. More generally it denotes the will to assert a right to private use of the land. In mountains the conditions are somewhat similar, with the additional feature of seasonal movement either of the herds alone

or with the whole population, which is properly " transhumance ". In the rest of continental Europe open fields and villages predominate. This, it may be remarked, though a geographical fact, is essentially a cultural phenomenon. Security has played its part ; archaeologists have long ago noticed the contrast of Roman tombs and barbarian cemeteries and the medieval village is often nested at the foot of the seigneurial castle. But there is amongst rural peoples throughout the world a deep feeling that the land really belongs only to him who tills it and that once harvested it shall revert to the community. In a simple system of self-sufficient husbandry, a biennial or triennial rotation of crops with bare fallow and *vaine pâture* ensures the subsistence of the people, the feeding of the cattle and the maintenance of fertility. The partition of the land in long strips has probably been favoured by the use of the heavy plough ; but a profound and universal sense of equity requires that when a field is divided it should be lengthwise. The whole system has proved remarkably stable for ages, until it was shaken and partly abolished by commercial economy and progressive farming.

In Chapter 15 on ' Agricultural Population, Crop Distribution and Productivity ' much use is necessarily made of statistics. The author is well aware of the deficiencies of this material. Figures for different countries are not equally reliable, nor obtained from exactly the same bases. Some criteria are not easily defined : what is exactly meant, for instance, by " population *directly* dependent on agriculture " ? Is " commercial farming " synonymous with " external trade " for all countries, small or large ? We are informed that the map, Fig. 28, of arable land, " is not statistically accurate and may be deceptive ". Even if accepted as an approximate expression of " facts ", each of such maps calls for a critical discussion, since similar effects may result from very different causes : sheep-rearing is a quite different business in the British Isles and in the Balkan and Hispanic peninsulas. This the author does especially in the final section of this chapter, ' Productivity of Agriculture ' (as expressed in " arable equivalents "). Some global data may convey false ideas : yields of wheat, for instance, are inevitably low where this cereal is cultivated on nearly every soil that will bear it. There remain, however, great differences in productivity between north-western and southern or eastern Europe. These are traceable to physical causes, but also to economic and technical factors. No doubt, high farming consists of " intensive cultivation properly integrated with a well-managed and specialised animal husbandry ". Progress of mechanisation depends, of course, on the supply of farm-labour and the economic status of the rural population, but also on the field pattern and the size of the holdings. In the U.S.S.R. a radical break with the past has freed rural life from such hindrances. In Western and Central Europe co-operation may promote rational management while preserving individual interest and initiative.

' Modern Transport and Communication ' by water, rail, road and air is discussed under its different aspects. Waterways are fully utilised in the central plain, from northern France to the Oder, and will eventually be farther east. Railway networks present various patterns—spider's web in France, in Russia and to a lesser degree in England, rectangular grid in Germany—which reflect physical, political and economic structures. Density of railway lines is very unequal from country to country, and density of traffic still more so. The relative importance of inland waterways and railways for transportation of freight is strikingly dissimilar : 9 to 1 in the Netherlands, 1 to 25 in Britain ! Seaports are best classified as to function : some are specialised in handling coal, fish or passenger traffic, while a few large ones, especially in the English Channel and Southern North Sea, are really universal in their activities and connections : they assume " a notable part of the world's shipping ".

Population, its distribution and density is obviously a basic datum of geography, but a datum only, since in itself it does not tell how far the population is dependent on the land : " in general it cannot be regarded as supported by the land it lives on ". Small scale maps may well show areas, zones or lines of higher density ; but detailed maps alone (Figs. 35, 36) will reveal whether similar densities mean rather uniform dispersion or concentration on a few privileged points. The main distinction is, of course, between rural and urban population, but the line is not easy to draw : the huge villages of the Hungarian plain with thousands of peasants in each are truly rural settlements, while modest groups of dwellings in suburbs of large cities are

integral parts of the urban complex. The town is better defined by its special functions and the mode of life of its inhabitants than by their number. Urban population has grown everywhere in Europe throughout the nineteenth century and after, but at very different rates : about 1815, it amounted already to 29 per. cent. of the total in England and Wales, and only 2 per cent in Russia ; the figures in 1925 were respectively 70 and 11. Rural population, on the other hand (Figs. 38, 39) has evolved differently. Up to about 1870 it increased nearly everywhere, but afterwards it decreased in France, Ireland and parts of England and Scotland : a very complex phenomenon in which are involved a negative rate of reproduction, exodus to cities and overseas emigration. These various and inter-acting factors are discussed, as well as the consequences of the losses of lives and wholesale transfers of population during and after the two wars, " the lasting effects of which can scarcely be foreseen ".

Thus far, various phenomena, natural and human, have been considered over the whole continent not only separately but also in their interdependence, so that " there has often been some attempt at correlation and even causation ". It remains to re-integrate these elements into their geographical complexes, that is regions each with its dominant characteristics : an arduous task, which inevitably involves some measure of convention and personal judgement in drawing limits. Natural phenomena sometimes vary rapidly within narrow spaces : these may then be taken as boundaries; linguistic limits are commonly linear and political frontiers still more so : " in the present state of human relations nationality has great importance, so the boundaries of sovereign states must be respected ". But the various limits that may be drawn are far from coinciding. " The most difficult tract to divide reasonably is the great plain. Important physical features, ultimately dependent on the climates of the Ice Age, moraines, marshes, sand-spreads and loess . . . lie concentrically upon the Baltic, the Great Lakes and the White Sea ". And the climatic zones, as defined by temperatures and aridity, especially in Russia, trend the same way. But the main rivers flow transversely to these zones, " and the various peoples have tended to be grouped along or near the rivers ", from the Rhine to the Dneiper and the Volga. Moreover " the former eastward colonisation by the Germans has left many marks ".

After careful consideration, a main limit is first drawn between the Mediterranean and borderlands (eastern and western) and Europe north of the Mediterranean. The latter is divided into six major regions : Danubian lands, Central Europe, Eastern plain, Scandinavian lands, France, British Isles with the northern isles. Between these there remain areas of transition and overlap where cultural and political pressures are felt, as suggested by arrows on the map : eastern Finland between Scandinavia and Russia ; Yugoslavia between the eastern bridgelands and the Danubian lands, and a very large tract covering the whole of the Alps and more than half of pre-war Germany. The major regions are then described (chapters 21-28) each with its internal contrasts and fundamental unity, in its present condition and possible developments. From the many pertinent remarks let us just cull these two. In the eastern bridgelands, pressure of population on cultivable land is extreme in Egypt, Israel and Greece, but Iraq needs a substantial increase of population to make large irrigation works profitable. " The Hapsburg Empire, politically infirm, was in the main geographically sound."

In these days when attention is focused on the future of Europe, the book should be welcome, for it offers, on an appropriately broad scale, a true picture of what Europe is with hints at what it could become. On closing it, one cannot but wonder how so much valuable material can be condensed in so few pages and at the same time presented in such a felicitous manner. This suggests a final remark. Ogilvie has on several occasions recommended co-operative research as the best means of obtaining reliable descriptions of little-known countries. But this process does not work well when it comes to regional synthesis, which is the final aim and proper essence of geography. Highly heterogeneous material has then to be sifted, probed and presented in such a manner that the parts appear in the whole and the whole in its parts : it has to go through a single mind endowed with broad knowledge, sound judgement and a sense of balance and harmony.

[1] *Europe and its Borderlands.* By Alan G. Ogilvie. 9¾ × 7¾. Pp. xii + 340. 46 Figs. Edinburgh, London : Thomas Nelson & Sons, Ltd. 1957. 42s.

[2] *S.G.M.* 70(1), 1954, pp. 1-5 and 34-35.

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integral parts of the urban complex. The town is better defined by its special functions and the mode of life of its inhabitants than by their number. Urban population has grown everywhere in Europe throughout the nineteenth century and after, but at very different rates : about 1815, it amounted already to 29 per. cent. of the total in England and Wales, and only 2 per cent in Russia ; the figures in 1925 were respectively 70 and 11. Rural population, on the other hand (Figs. 38, 39) has evolved differently. Up to about 1870 it increased nearly everywhere, but afterwards it decreased in France, Ireland and parts of England and Scotland : a very complex phenomenon in which are involved a negative rate of reproduction, exodus to cities and overseas emigration. These various and inter-acting factors are discussed, as well as the consequences of the losses of lives and wholesale transfers of population during and after the two wars, " the lasting effects of which can scarcely be foreseen ".

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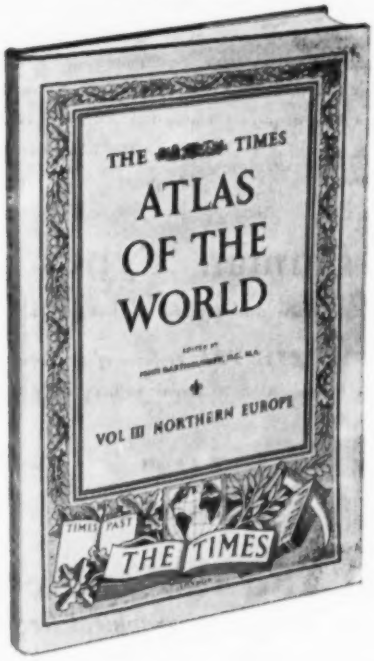

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